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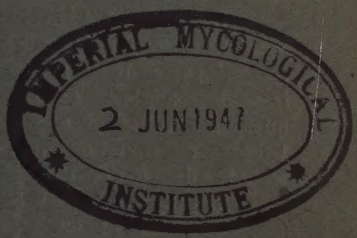

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MATHEMATIK

ÜBER DIE POINCARÉSCHE RANDWERTAUFGABE DES LOGARITHMISCHEN POTENTIALS

Von B. CHWEDELIDSE

(Vorgelegt von N. I. Muskhelishvili, Mitglied der Akademie, den 14. X. 1940)

§ 1. Bei der Entwicklung der mathematischen Fluttheorie kam Poincaré (1) auf die folgende Randwertaufgabe. Es sei T ein endliches Gebiet, das von einer einfachen geschlossenen Kurve L begrenzt wird. Es wird eine in T harmonische und in $T+L$ mit ihren ersten Ableitungen stetige Funktion u gesucht, die der Randbedingung

$$\frac{du}{dn}+p(s)\frac{du}{ds}+q(s)u+f(s)=0 \qquad (1)$$

genügt, wobei s den Bogen der Randkurve L, $p(s)$, $q(s)$, $f(s)$ gegebene Funktionen der Kurvenpunkte, n — die innere Normale bezeichnet.

Eine erschöpfende Lösung dieser Aufgabe gibt Poincaré nicht. G. Bertrand (2) untersucht den Speziellfall $q(s)\equiv 0$, $p(s)=iA(s)$, wobei $A(s)$ eine reelle Funktion ist [aus dem Zusammenhang seines Textes zu schliessen, hält Bertrand die Funktionen $A(s)$ und $f(s)$ für analytisch]. Auf diesen Fall führt eine der Grundaufgaben der Fluttheorie. Im Falle $1-A^2(s)\neq 0$ führt Bertrand das Problem auf eine reguläre Fredholmsche Gleichung zurück, indem er die Poincarésche Methode präzisiert.

In einer 1938 erschienenen Arbeit betrachtet Pogorzelski (3) das Problem (1) für eine analytische Randkurve L, indem er überdies $p(s)$, $q(s)$, $f(s)$ als reelle analytische Funktionen annimmt. Er konstruiert die reguläre Fredholmsche Integralgleichung, welche der singulären, die Aufgabe lösenden Integralgleichung, äquivalent ist, lässt aber die Frage über die Existenz und die Eindeutigkeit der Lösung offen.

Unter Benutzung einer kürzlich erschienenen Arbeit von I. Vecoua (4) gebe ich in der vorliegenden Note die vollständige Lösung der Poincaréschen Aufgabe für den Fall, dass die Funktionen $p(s)$, $q(s)$, $f(s)$ reell sind, wobei über die Randkurve L weniger weitgehende Annahmen gemacht werden. Zum Schluss der Note (§ 3) zeige ich, dass die gewonnenen Ergebnisse auf komplexe Funktionen $p(s)$, $q(s)$, $f(s)$ übertragen werden können, wobei sich als Sonderfall auch die Bertrandsche Lösung ergibt.

§ 2. Die Kurve L besitze eine stetige Krümmung, und die Funktionen $p(s)$, $q(s)$, $f(s)$ mögen auf L der Hölderschen Bedingung genügen.

Wir setzen nun die gesuchte Funktion u in Gestalt eines Potentials einer einfachen Schicht mit der stetigen Dichte $\mu(t)$:

$$u(A) = \int_L \mu(t) \lg \frac{1}{r_t} dt \tag{2}$$

wobei r_t die Entfernung vom Punkte A des Gebiets T bis zum Integrationspunkt $Q(t)$ der Kurve L bezeichnet. Bekanntlich bleibt das Integral auch auf der Kurve stetig. Strebt ferner A gegen einen festen Randpunkt $P(s)$, so gelten die folgenden Formeln:

$$\left(\frac{du}{dn}\right)_P = \int_L \mu(t) \frac{\sin \varphi_s}{r_{st}} dt - \pi\mu(s), \qquad \left(\frac{du}{ds}\right)_P = \int_L \mu(t) \frac{\cos \varphi_s}{r_{st}} dt. \tag{3}$$

Hierbei bezeichnet r_{st} die Entfernung zwischen den Punkten $P(s)$ und $Q(t)$ und φ_s den Winkel zwischen dem Vektor $\overrightarrow{PQ}$ und der positiven Tangentenrichtung im Punkte $P(s)$.

Infolge der Bedingungen, die der Randkurve auferlegt sind, ist $\frac{\sin \varphi_s}{r_{st}}$ eine stetige Funktion von s und t, und $\frac{\cos \varphi_s}{r_{st}}$ wächst bei der Annäherung $s \to t$ wie $\frac{1}{s-t}$. Daher wird das zweite Integral (3) als Cauchyscher Hauptwert genommen. Um die Gültigkeit dieser Formel zu sichern, verlangen wir, dass die Dichte $\mu(t)$ der Hölderschen Bedingung genüge (diese Forderung soll später gerechtfertigt werden).

Setzt man die Ausdrücke (2), (3) in (1) ein, so bekommt man eine singuläre Integralgleichung

$$-\pi\mu(s) + \int_L \left[\frac{\sin \varphi_s}{r_{st}} + p(s) \frac{\cos \varphi_s}{r_{st}} + q(s) \lg \frac{1}{r_{st}}\right] \mu(t)\, dt + f(s) = 0 \tag{4}$$

das Integral als Cauchyscher Hauptwert genommen. Schreiben wir Gl. (4) in der Form

$$\mu(s) - \frac{1}{\pi} \int_L R(s,t)\, \mu(t)\, dt = \frac{f(s)}{\pi} \tag{4'}$$

wo

$$R(s,t) = \frac{\sin \varphi_s}{r_{st}} + p(s) \frac{\cos \varphi_s}{r_{st}} + q(s) \lg \frac{1}{r_{st}} \tag{5}$$

und führen statt der Bogen s und t entsprechende Anhängsel σ und τ ein.

Wird der vom Vektor $\overrightarrow{\sigma\tau}$ mit der Ox-Achse gebildete Winkel durch ϑ bezeichnet, so gilt $r_{st} = (\tau - \sigma) e^{-i\vartheta}$. Hieraus folgt

$$R(s,t) = R_1(\sigma, \tau) = \frac{[\sin \varphi_\sigma + p_1(\sigma) \cos \varphi_\sigma] e^{i\vartheta} - q_1(\sigma)(\tau - \sigma) \lg |\tau - \sigma|}{\tau - \sigma}$$

mit

$$p_1(\sigma) = p(s(\sigma)), \qquad q_1(\sigma) = q(s(\sigma))$$

und die Integralgleichung (4') geht in

$$\rho(\sigma) - \frac{1}{\pi} \int_L \frac{K(\sigma, \tau)}{\tau - \sigma} \rho(\tau)\, d\tau = g(\sigma) \tag{6}$$

über, wobei

$$K(\sigma, \tau) = [\sin \varphi_\sigma + p_1(\sigma) \cos \varphi_\sigma] e^{i(\vartheta - \psi)} - q_1(\sigma)(\tau - \sigma) e^{-i\psi} \lg |\tau - \sigma|, \tag{7}$$

$$\rho(\sigma) = \mu(s(\sigma)), \qquad g(\sigma) = \frac{f(s(\sigma))}{\pi}.$$

Der Winkel ψ wird hierbei von der positiven Tangentenrichtung in $Q(\tau)$ mit der Ox-Achse gebildet. Aus unseren Annahmen folgt, dass die Funktion $K(\sigma, \tau)$ mit bezug auf beide Veränderliche σ und τ der Hölderschen Bedingung genügt.

Wir betrachten nun die folgende allgemeinere Gleichung:

$$\alpha(\sigma)\varphi(\sigma) - \lambda \int_L \frac{K(\sigma, \tau)}{\tau - \sigma} \varphi(\tau)\, d\tau = f(\sigma) \qquad (*)$$

wobei $K(\sigma, \tau)$, $\alpha(\sigma)$, $f(\sigma)$ gegebene Funktionen sind, die der Hölderschen Bedingung bezüglich σ und τ genügen, λ ein konstanter Parameter ist, und das Integral als Cauchyscher Hauptwert genommen wird.

Vecoua [4] zeigte: wird

$$\alpha^2(\sigma) + \lambda^2\pi^2\beta^2(\sigma) \neq 0 \quad \text{mit} \quad \beta(\sigma) = K(\sigma, \sigma)$$

und

$$\operatorname{ind} a(\sigma) = \frac{1}{2\pi i} \int_L d \lg a(\sigma) = -m \leqslant 0 \quad \text{mit} \quad a(\sigma) = \frac{\alpha(\sigma) - \lambda\pi i\beta(\sigma)}{\alpha(\sigma) + \lambda\pi i\beta(\sigma)}$$

angenommen, so ist die Integralgleichung (*) der folgenden regulären Fredholmschen Integralgleichung gleichwertig, in der die willkürlichen Konstanten $a_1, a_2, \ldots, a_m$ linear auftreten:

$$\varphi(\sigma) - \lambda \int_L K^*(\sigma, \tau)\varphi(\tau)\, d\tau = f^*(\sigma) + P_{m-1}(\sigma) f_0(\sigma) \qquad (**)$$

wo

$$K^*(\sigma, \tau) = \frac{1}{2}\left[\frac{1}{\alpha(\sigma) + 2\pi i\beta(\sigma)} + \frac{1}{\alpha(\sigma) - \lambda\pi i\beta(\sigma)}\right] \frac{K(\sigma, \tau) - K(\sigma, \sigma)}{\tau - \sigma} +$$

$$+ \left[\frac{1}{\sqrt{a(\sigma)}} - \sqrt{a(\sigma)}\right] \sigma^{\frac{m}{2}} e^{-\omega(\sigma)} \frac{1}{2\pi i} \int_L \frac{\tau_1^{-\frac{m}{2}} e^{\omega(\tau_1)}}{\sqrt{\alpha^2(\tau_1) + \lambda^2\pi^2\beta(\tau_1)}} \cdot \frac{K(\tau_1, \tau) - K(\tau, \tau)}{\tau - \tau_1} \cdot \frac{d\tau_1}{\tau_1 - \sigma},$$

$$f^*(\sigma) = \frac{1}{2}\left[\frac{1}{\alpha(\sigma) + \lambda\pi i\beta(\sigma)} + \frac{1}{\alpha(\sigma) - \lambda\pi i\beta(\sigma)}\right] f(\sigma) +$$

$$+ \left[\frac{1}{\sqrt{a(\sigma)}} - \sqrt{a(\sigma)}\right] \sigma^{\frac{m}{2}} e^{-\omega(\sigma)} \cdot \frac{1}{2\pi i} \int_L \frac{\tau^{-\frac{m}{2}} e^{\omega(\tau)}}{\sqrt{\alpha^2(\tau) + \lambda^2\pi^2\beta^2(\tau)}} \cdot \frac{f(\tau)}{\tau - \sigma}\, d\tau,$$

$$P_{m-1}(z) = a_1 + a_2 z + \ldots + a_m z^{m-1},$$

$$f_0(\sigma) = \left[\frac{1}{\sqrt{a(\sigma)}} - \sqrt{a(\sigma)}\right] \sigma^{-\frac{m}{2}} e^{-\omega(\sigma)}, \quad \omega(\sigma) = \frac{1}{2\pi i} \int_L \frac{\lg[\tau^m a(\tau)]}{\tau - \sigma}\, d\tau.$$

Alle Lösungen der Gleichung (**) genügen der Hölderschen Bedingung. (Ich hielt es für zweckmässig, die Vecouaschen Formeln wiederzugeben, da sich in seine Arbeit einige Fehler eingeschlichen haben, die mir vom Verf. mitgeteilt wurden).

Wir wenden jetzt das obige Ergebnis an. Da in unserem Falle

$$\lambda = \frac{1}{\pi}, \quad \alpha(\sigma) = 1, \quad \beta(\sigma) = K(\sigma, \sigma) = p_1(\sigma), \quad \alpha^2(\sigma) + \lambda^2\pi^2\beta^2(\sigma) = 1 + p_1^2(\sigma) \neq 0$$

[da $p_1(\sigma)$ eine reelle Funktion ist] und $-m = \operatorname{ind} \dfrac{1 - ip_1(\sigma)}{1 + ip_1(\sigma)} = 0$ ist, so ist Gl. (6) der folgenden regulären Fredholmschen Integralgleichung

$$\rho(\sigma) - \frac{1}{\pi} \int_L K^*(\sigma, \tau)\rho(\tau)\, d\tau = g^*(\sigma) \qquad (8)$$

gleichwertig, wo

$$K^*(\sigma,\tau)=\frac{1}{2}\left[\frac{1}{1+ip_1(\sigma)}+\frac{1}{1-ip_1(\sigma)}\right]\frac{K(\sigma,\tau)-p_1(\sigma)}{\tau-\sigma}+$$

$$+\left[\frac{1}{\sqrt{a(\sigma)}}-\sqrt{a(\sigma)}\right]e^{-\omega(\sigma)}\frac{1}{2\pi i}\int_L\frac{e^{\omega(\tau_1)}}{\sqrt{1+p_1^2(\tau_1)}}\cdot\frac{K(\tau_1,\tau)-p_1(\tau)}{\tau-\tau_1}\cdot\frac{d\tau_1}{\tau_1-\sigma},$$

$$g^*(\sigma)=\frac{1}{2}\left[\frac{1}{1+ip_1(\sigma)}+\frac{1}{1-ip_1(\sigma)}\right]g(\sigma)+$$

$$+\left[\frac{1}{\sqrt{a(\sigma)}}-\sqrt{a(\sigma)}\right]e^{-\omega(\sigma)}\frac{1}{2\pi i}\int_L\frac{e^{\omega(\tau)}}{\sqrt{1+p_1^2(\tau)}}\cdot\frac{g(\tau)}{\tau-\sigma}d\tau$$

und alle Lösungen von (8) der Hölderschen Bedingung genügen. Damit Gl. (8) der gestellten Aufgabe (1) entspreche, genügt es z. B. zu verlangen, dass die normale Ableitung der gesuchten Funktion der Hölderschen Bedingung genüge. In diesem Falle ist nämlich die gesuchte Funktion als Potential einer einfachen Schicht darstellbar, wobei die Dichte der Hölderschen Bedingung genügt.

Diese Beschränkung wird in all den Fällen überflüssig, wo die Eindeutigkeit der Lösung unserer Aufgabe (1) unmittelbar eingesehen werden kann. Dann hat nämlich, wie sich nachweisen lässt, auch die Gl. (8) eine einzige Lösung, welche das Problem (1) löst. Einer von diesen Fällen tritt ein, wenn die Funktion $p(s)$ eine integrierbare Ableitung besitzt, wobei

$$\frac{dp(s)}{ds}-2q(s)\geqslant 0,\quad q(s)\not\equiv 0. \tag{9}$$

In der Tat, sind u_1 und u_2 zwei Lösungen von (1), so genügt ihre Differenz $v=u_1-u_2$ auf L der Bedingung

$$\frac{dv}{dn}+p(s)\frac{dv}{ds}+q(s)v=0. \tag{10}$$

Auf Grund der bekannten Formel

$$\iint_T\left\{\left(\frac{\partial v}{\partial x}\right)^2+\left(\frac{\partial v}{\partial y}\right)^2\right\}dxdy+\int_L v\frac{dv}{dn}ds=0$$

und der Bedingung (10), hat man dann

$$\iint_T\left\{\left(\frac{\partial v}{\partial x}\right)^2+\left(\frac{\partial v}{\partial y}\right)^2\right\}dxdy+\int_L\left\{\frac{1}{2}\frac{dp}{ds}-q\right\}v^2ds=0. \tag{11}$$

Wendet man hierauf (9), (10) und (11) an, so folgt $v\equiv 0$.

§ 3. Alle unsere Überlegungen bleiben auch dann gültig, wenn $q(s)$, $f(s)$ beliebige komplexe Funktionen sind, die der Hölderschen Bedingung genügen, und $p(s)=iA(s)$ ist, wobei die reelle Funktion $A(s)$ ebenfalls der Hölderschen Bedingung genügt und $1-A^2(s)\neq 0$ ist. In der Tat, setzt man unter diesen Annahmen $A_1(\sigma)=A(s(\sigma))$, so folgt

$$\alpha^2=\lambda^2\pi^2\beta^2=1+p_1^2(\sigma)=1-A_1^2(\sigma)\neq 0,$$

$$\operatorname{ind}a(\sigma)=\operatorname{ind}\frac{1+A_1(\sigma)}{1-A_1(\sigma)}=0.$$

Wie gesagt, schliesst dieser Fall den von Bertrand untersuchten als Speziellfall ein.

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[1] H. Poincaré, Leçons de Mécanique Céleste, III, ch. X, Paris (1910). [2] G. Bertrand, Ann. Sc. de l'Ec. Norm. Sup., 3 sér., 40 (1923). [3] W. Pogorzelski, Math. ZS., 44 (1939). [4] I. Vecoua, C. R. Acad. Sci. URSS, XXVI, No. 4 (1940).

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MATHEMATICS

ON SCHNIRELMANN'S TRANSFORMATIONS

By GEORGE CHOGOSHVILI

(Communicated by S. L. Soboleff, Member of the Academy, 14. X. 1940)

L. Schnirelmann set a problem to study such deformations of hypersurfaces of Riemann's n-dimensional manifolds, as run like the deformations of level surfaces of a non-degenerated function given on a manifold.

Below there is given a definition of such deformations (not only for hypersurfaces of dimensionality $n-1$, but also for those of any dimensionality $r \leqslant n-1$) and is shown in which way their study from the topological point of view may be reduced to a study of level surfaces; finally, basing upon the preceding works ([1],[2],[4],[5],[6]) dealing with level surfaces, we give the possible changes of certain invariants, for instance the Betti numbers of deforming hypersurfaces.

Let an r-dimensional hypersurface M_t^r, $1 \leqslant r \leqslant n-1$, of a n-dimensional Riemann's space ([3], p. 15) correspond to every value of the parameter t, $t_1 \leqslant t \leqslant t_2$, in such a way, that each set M_t^r separately and their system $\{M_t^r\}$ as a whole would satisfy the conditions formulated hereafter.

Let us take an arbitrary point $p \subset M_t^r$ and a neighbourhood U of this point in M^n, which is homeomorphic to a n-dimensional Euclidian space and into which a local co-ordinate system $(x_1, \ldots, x_n)$ is introduced. Each set M_t^r corresponding to the value t chosen within a certain sufficiently small interval (t', t''), $t' < t < t''$, must have a non-vacuous intersection with U, the part of M_t^r in U being represented by a system of equations

$$f_i(x_1, \ldots, x_n, t) = 0, \quad i = 1, 2, \ldots, n-r,$$

where the functions f_i have derivatives up to necessary orders. The Jacobian

$$\mu = \left\| \begin{array}{c} \frac{\partial f_1}{\partial x_1}, \ldots, \frac{\partial f_1}{\partial x_n} \\ \ldots\ldots\ldots\ldots \\ \frac{\partial f_{n-r}}{\partial x_1}, \ldots, \frac{\partial f_{n-r}}{\partial x_n} \end{array} \right\|$$

of the system has, for almost all t and for all $p \subset M_t^r$, the rank $n-r$. Only for a finite number of values of t and for a finite number of points $p \subset M_t^r$ is its rank $\mu = n-r-1$. Such values of t we call the critical values of the parameter and such points, the critical points of the system $\{M_t^r\}$.

When t runs continuously over all values from t_1 up to t_2, then we have topological deformation M_t^r outside arbitrarily small neighbourhoods of the critical points; in other words, the one-to-one correspondence or continuity of transformation is broken nowhere but in an arbitrarily small neighbourhood of the critical point. Now we shall give the analytic conditions which should be satisfied in order for such breaks to take place, while the geometrical character of the breaks will become clear after our problem is reduced to the one of level surfaces already studied ([4–6]).

The condition imposed on the rank of matrix μ (the discriminant of the tangent plane to M_t^r at p) shows that this tangent plane is a non r-dimensional one at a non-critical point and has $r+1$ dimensions at a critical point.

Let p be a critical point corresponding to a critical value t^* of parameter t, and let a local co-ordinate system $(x_1, \ldots, x_n)$ in neighbourhood U of p be chosen in such a way, that the first $r+1$ axes $x_1, \ldots, x_{r+1}$ should lie on the $(r+1)$-dimensional tangent plane of M_t^r at p. In this case, at least one of the determinants of $(n-r-1)$-th order of the matrix μ composed of partial differential coefficients with regard to $x_{r+2}, \ldots, x_n$ should not vanish. Assume this to be determinant Δ, elements of which are partial differential coefficients of $f_1, \ldots, f_{n-r-1}$. So at the point p the determinant

$$\Delta = \begin{vmatrix} \frac{\partial f_1}{\partial x_{r+2}}, & \ldots, & \frac{\partial f_1}{\partial x_n} \\ \ldots & \ldots & \ldots \\ \frac{\partial f_{n-r-1}}{\partial x_{r+2}}, & \ldots, & \frac{\partial f_{n-r-1}}{\partial x_n} \end{vmatrix} \neq 0.$$

Consider the determinants

$$\Delta_i = \begin{vmatrix} \frac{\partial f_1}{\partial x_i}, & \frac{\partial f_1}{\partial x_{r+2}}, & \ldots, & \frac{\partial f_1}{\partial x_n} \\ \ldots & \ldots & \ldots & \ldots \\ \frac{\partial f_{n-r-1}}{\partial x_i}, & \frac{\partial f_{n-r-1}}{\partial x_{r+2}}, & \ldots, & \frac{\partial f_{n-r-1}}{\partial x_n} \\ \frac{\partial f_{n-r}}{\partial x_i}, & \frac{\partial f_{n-r}}{\partial x_{r+2}}, & \ldots, & \frac{\partial f_{n-r}}{\partial x_n} \end{vmatrix}, \quad i = 1, 2, \ldots, r+1,$$

and the determinant Δ_t which differs from Δ_i in having in the first column elements $\frac{\partial f_1}{\partial t}, \ldots \frac{\partial f_{n-r-1}}{\partial t}, \frac{\partial f_{n-r}}{\partial t}$ instead of elements $\frac{\partial f_1}{\partial x_i}, \ldots,$ $\frac{\partial f_{n-r-1}}{\partial x_i}, \frac{\partial f_{n-r}}{\partial x_i}$, respectively. We assume besides that

$$\left| \frac{\partial \Delta_i}{\partial x_j} \right| \neq 0, \quad i, j = 1, 2, \ldots, r+1$$

and that $\Delta_t \neq 0$.

As an example of a system $\{M_t^r\}$ satisfying the above-mentioned conditions, may serve a totality of level surfaces of a non-degenerated function, given on a manifold.

Let us project the considered parts of hypersurfaces M_t^r (i. e. the parts M_t^r lying in U) for each $t, t' < t < t''$, orthogonally on the tangent plane, i. e. on the co-ordinate plane $(x_1, \ldots, x_{r+1})$. To obtain the equations of these projections we have to eliminate the $x_{r+2}, \ldots, x_n$ from the equations determining the M_t^r. To show the possibility of

accomplishing it, take on each M_t^r, $t' < t < t''$, a single point p_t, $p_{t^*} = p$, so that $p_t \to p$, while $t \to t^*$, and consider the system of $n-r-1$ functions:

$$f_i(x_1, \ldots, x_{r+1}, x_{r+2}, \ldots, x_n, t), \quad i = 1, \ldots, n-r-1.$$

These functions vanish at p_t, possess continuous partial differential coefficients with respect to all arguments, and the determinant composed of their partial differential coefficients in respect to the last $n-r-1$ arguments $x_{r+2}, \ldots, x_n$ is not zero in the neighbourhood of p_t. Therefore there exists a unique system of functions $x_i = \varphi_i(x_1, \ldots, x_{r+1}, t)$, $i = r+2, \ldots, n$, that turn the equations

$$f_j(x_1, \ldots, x_n, t) = 0, \quad j = 1, \ldots, n-r-1$$

into identities, and have, for the values of arguments equal to the first $r+1$ co-ordinates of the point p_t, the values of the remaining co-ordinates of the same point.

Substituting the expressions found for x_i, $i = r+2, \ldots, n$, into the remaining equation $f_{n-r}(x_1, \ldots, x_{r+1}, x_{r+2}, \ldots, x_n, t) = 0$, we shall obtain

$$f_{n-r}(x_1, \ldots, x_{r+1}, \varphi_{r+2}(x_1, \ldots, x_{r+1}, t), \ldots, \varphi_n(x_1, \ldots, x_{r+1}, t), t) = 0$$

or

$$f(x_1, \ldots, x_{r+1}, t) = 0$$

which is just an equation in the co-ordinate plane $(x_1, \ldots, x_{r+1})$ of the projection of considered part of surface M_t^r on this plane.

We have:

$$\frac{\partial f}{\partial t} = \frac{\partial f_{n-r}}{\partial t} = \frac{\partial f_{n-r}}{\partial x_{r+2}} \cdot \frac{\partial \varphi_{r+2}}{\partial t} + \ldots + \frac{\partial f_{n-r}}{\partial x_n} \cdot \frac{\partial \varphi_n}{\partial t} + \frac{\partial f_{n-r}}{\partial t}.$$

To obtain the values $\frac{\partial \varphi_i}{\partial t}$, $i = r+2, \ldots, n$, let us substitute the same functions $x_i = \varphi_i(x_1, \ldots, x_{r+1}, t)$, $i = r+2, \ldots, n$, into the equations $f_j(x_1, \ldots, x_n, t) = 0$, $j = 1, \ldots, n-r-1$, thus turning the latter into identities

$$f_j(x_1, \ldots, x_{r+1}, \varphi_{r+2}(x_1, \ldots, x_{r+1}, t), \ldots, \varphi_n(x_1, \ldots, x_{r+1}, t), t) \equiv 0.$$

Differentiate all these identities with respect to t:

$$\frac{\partial f_j}{\partial x_{r+2}} \cdot \frac{\partial \varphi_{r+2}}{\partial t} + \ldots + \frac{\partial f_j}{\partial x_n} \cdot \frac{\partial \varphi_n}{\partial t} = -\frac{\partial f_j}{\partial t}, \quad j = 1, 2, \ldots, n-r-1.$$

The determinant of this system of $n-r-1$ equations with $n-r-1$ unknown $\frac{\partial \varphi_i}{\partial t}$ does not vanish in the neighbourhood of p. Consequently

$$\frac{\partial \varphi_i}{\partial t} = -\frac{\delta_i}{\Delta}$$

where

$$\delta_i = \begin{vmatrix} \frac{\partial f_1}{\partial x_{r+2}}, \ldots, \frac{\partial f_1}{\partial x_{i-1}}, \frac{\partial f_1}{\partial t}, \frac{\partial f_1}{\partial x_{i+1}}, \ldots, \frac{\partial f_1}{\partial x_n} \\ \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \\ \frac{\partial f_{n-r-1}}{\partial x_{r+2}}, \ldots, \frac{\partial f_{n-r-1}}{\partial x_{i-1}}, \frac{\partial f_{n-r-1}}{\partial t}, \frac{\partial f_{n-r-1}}{\partial x_{i+1}}, \ldots, \frac{\partial f_{n-r-1}}{\partial x_n} \end{vmatrix}.$$

Substituting these values of $\frac{\partial \varphi_i}{\partial t}$ into the expressions for $\frac{\partial f}{\partial t}$, we obtain:

$$\frac{\partial f}{\partial t} = \frac{1}{\Delta}\left\{\frac{\partial f_{n-r}}{\partial t}\Delta - \sum_{i=r+2}^{n}\frac{\partial f_{n-r}}{\partial x_i}\delta_i\right\}.$$

Let δ^i denote the determinant obtained from δ_i by taking the column of the partial differential coefficients with respect to t for the first column. We have:

$$\frac{\partial f}{\partial t} = \frac{1}{\Delta}\left\{\frac{\partial f_{n-r}}{\partial t}\Delta + \sum_{i=r+2}^{n}(-1)^{i-r-1}\frac{\partial f_{n-r}}{\partial x_i}\delta^i\right\} = \pm\frac{\Delta_t}{\Delta}.^{*}$$

Therefore $\frac{\partial f}{\partial t}$ is not zero in a sufficiently small neighbourhood of p on the plane $(x_1, \ldots, x_{r+1})$, when t is near enough to t^*, for neither Δ nor Δ_t vanish at p, according to the assumption.

This makes it possible to represent the equation of our family in the neighbourhood of p and for values of parameter t neighbouring to t^* in the form

$$\varphi(x_1, \ldots, x_{r+1}) = t.$$

Thus, in a definite neighbourhood of p there is given a function which assumes the value $\varphi(x_1, \ldots, x_{r+1}) = t$ at the point $(x_1, \ldots, x_{r+1})$ of this neighbourhood, and whose level surface under the value of t coincides with the projection of the part of M_t^r in question.

It remains to show that $\varphi(x_1, \ldots, x_{r+1})$ is a non-degenerated function, having as its critical point (evidently unique in considered neighbourhood) the point p.

In the same way in which we have calculated the $\frac{\partial f}{\partial t}$, we shall show that $\frac{\partial f}{\partial x_i} = \pm\frac{\Delta_i}{\Delta}$ and, consequently, $\frac{\partial f}{\partial x_i} = 0$, as $\Delta_i = 0$ and $\Delta \neq 0$. Hence we conclude that $\frac{\partial \varphi}{\partial x_i} = 0$, $i = 1, \ldots, r+1$ $\left(\text{as } \frac{\partial f}{\partial t} \neq 0\right)$, i. e. that p is a critical point of the function φ. To show that at p

$$\left|\frac{\partial^2 \varphi}{\partial x_i \partial x_j}\right| \neq 0, \quad i, j = 1, \ldots, r+1,$$

we shall note, first, that at p

$$\left|\frac{\partial^2 \varphi}{\partial x_i \partial x_j}\right| = \frac{1}{\left(-\frac{\partial f}{\partial t}\right)^{r+1}}\left|\frac{\partial^2 f}{\partial x_i \partial x_j}\right|,$$

and, secondly, that

$$\frac{\partial^2 f}{\partial x_i \partial x_j} = \pm\frac{\partial}{\partial x_j}\left(\frac{\Delta_i}{\Delta}\right) = \pm\frac{1}{\Delta}\frac{\partial \Delta_i}{\partial x_j}$$

so that

$$\left|\frac{\partial^2 f}{\partial x_i \partial x_j}\right| = \pm\frac{1}{\Delta^{r+1}}\left|\frac{\partial \Delta_i}{\partial x_j}\right|.$$

Thus, in p

$$\left|\frac{\partial^2 \varphi}{\partial x_i \partial x_j}\right| = \pm\frac{1}{\left(\Delta\frac{\partial f}{\partial t}\right)^{r+1}}\left|\frac{\partial \Delta_i}{\partial x_j}\right| \neq 0$$

for under assumption neither of factors vanish.

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* The sign $+$, if $n-r$ is odd, and the sign $-$, if $n-r$ is even.

The point p, as a non-degenerated critical point of the function φ, has a certain index k. This number k we shall call the index of the critical point p of Schnirelmann's transformation $\{M_t^r\}$ with which we are concerned.

The considered parts of the surfaces M_t^r (i. e. the subsets M_t^r, confined in a sufficiently small, finally chosen neighbourhood of p) are homeomorphic to their projections on the tangent plane of $M_{t^*}^r$ at p, and so we can, up to a homeomorphism, consider their projections instead of them, i. e. identify the parts of surfaces M_t^r with their projections. The parts complementing the considered ones up to M_t^r may be left without change, for they represent topologically deforming manifolds. So, for ascertaining the topological nature of modification suffered by the set M_t^r, when t passes through t^*, we may proceed exactly in the same way as before ([4]), while investigating the same question in case of level surfaces. The modification of M_t^r, while passing through a critical point of index k, is similar from topological point of view to the modification of level surface of a non-degenerated function of $r+1$ variables, when it is passing through a critical point of index k.

Hence and from ([4]) we conclude, in particular, that if for the system $\{M_t^r\}$ in a closed interval $[t', t'']$ the parameter t has a single critical value t^*, $t' < t^* < t''$, corresponding to the critical point of index k, we have, denoting by Δp^i the difference between the i-dimensional Betti numbers of manifolds $M_{t'}^r$ and $M_{t''}^r$, one of the four possible cases:

$$\text{I. } \Delta p^{k-1} = -1,\ \Delta p^{r-k} = 1; \qquad \text{III. } \Delta p^k = 1,\ \Delta p^{r-k} = 1;$$
$$\text{II. } \Delta p^{k-1} = -1,\ \Delta p^{r-k+1} = -1; \qquad \text{IV. } \Delta p^k = 1,\ \Delta p^{r-k+1} = -1;$$

in each case $\Delta p^i = 0$ for the remaining i. In case $r = 2k,\ 2k-1,\ 2k-2$ the difference can be equal to the number $2, -2, 0$, as well. If $M_{t'}^r$ and $M_{t''}^r$ are closed, the cases I and IV can no longer take place.

About some other invariants for M_t^r see ([6]).

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PHYSICS

ON THE METHOD OF ISOTOPE SEPARATION WITH THE AID OF A LINEAR ACCELERATOR

By D. ALKHAZOV and A. MURIN

(Communicated by V. G. Khlopin, Member of the Academy, 2. X. 1940)

Alvarez and Cornog (1) used the cyclotron as a mass spectrograph, thus demonstrating the practicability of separating isotopes by means of a resonance accelerator. The theory of the motion of ions in the cyclotron was developed in full detail (2), and little doubt arises as to conditions under which the cyclotron may be used as a mass spectrograph.

Besides the cyclotron, another resonance appliance, viz. the linear accelerator of Sloan and Lawrence (3), may serve the purpose of mass spectrography. As compared to Dempster's mass spectrograph, the linear accelerator permits of a better utilization of the ion source and accelerates the ions to higher energies, the space charge being therefore decreased. Although in the accelerator the current flow is not continuous, but takes place during a portion of the radiofrequency cycle, nevertheless it may be expected that the linear accelerator will have advantages over the ordinary mass spectrograph as far as intensity is concerned.

In the linear accelerator the ion passes consecutively through a number of acceleration regions between neighbouring electrodes. As a result of n accelerations the energy E of the ion will be:

$$E = 2eU_0 \int_0^n \cos\theta \, dn; \qquad (1)$$

e, the ion charge; $2U_0$, the amplitude of the difference of potentials between electrodes; θ, the phase of the electric field at the moment of acceleration. The phase change from one acceleration to another:

$$\frac{d\theta}{dn} = \pi \left[\frac{\left(\frac{m}{m_0}\right)^{\frac{1}{2}}}{\left(\frac{1}{n}\int_0^n \cos\theta \, dn\right)^{\frac{1}{2}}} - 1 \right] \qquad (2)$$

where m_0 is the mass of the ion moving in resonance to the electric field. The equation (2) permits, provided the initial $\theta(1)$ is known, a calculation of $\theta(n)$ by means of elementary numerical integration.

The angle α formed by the trajectory of the ion and the axis of the accelerator will change when the ion traverses the acceleration region. If we regard the region between electrodes as a thin ionic lens and consider the paraxial ions alone, the following equation is obtained:

$$\frac{d\alpha}{dn} = -\frac{reU_0}{2E_c} \cdot \frac{\omega}{v} \sin\theta - \frac{3re^2 \cos^2\theta}{16 E_c^2} \int_{-l}^{l} \left(\frac{\partial V_0}{\partial z}\right)^2 dz; \; (E_c \gg eU_0) \qquad (3)$$

where r is the distance of the ion from the axis, E_c the energy and v

velocity of the ion in the middle of the lens; ω is the cyclic frequency of the radiogenerator; $\frac{\partial V_0}{\partial z}$ is the field intensity at the lens axis and $2l$ is the lens length. From (3) it follows that similarly to the case of motion of ions in the cyclotron, the ion beam is focussed $\left(\frac{d\alpha}{dn} < 0\right)$ at positive and small negative (absolute values) θ. At ion velocities close to the resonance value, the focussing is effected if

$$\frac{\sin\theta}{\cos^2\theta} > -\frac{1}{k\pi} \cdot \frac{eU_0}{E} \cdot \frac{l(n)}{2l}$$

where k is the multiple of the frequency (see below) and $l(n)$ is the length of the n-th electrode. In the case of first accelerations ($n < 5$) the equation (3) may serve only as a rough approximation.

For the separation of isotopes it is expedient to operate not on the basic resonance frequency, but on its multiple, in order to reduce the number of accelerating electrodes. If, for instance, the linear accelerator is used for the purpose of separating the isotopes Ur_{235} and Ur_{238}, then the radiowave length is found to be 16 m, provided the length of the first electrode is 10 cm, the amplitude of the difference of potentials is 40 kV and the frequency is 20 times the multiple of the basic frequency. The phase change is 20 times that calculated according to the formula (2).

The energies of ions leaving the accelerator after three accelerations:

$E \times (40\,\text{ekV})^{-1}$ \ θ (1)	$-6°$	$-5°$	$-4°$	$-3°$	$-2°$	$-1°$	0	$1°$	$2°$	$3°$	$4°$	$5°$	$6°$
Ur_{235}	2.97	—	—	—	—	—	3	—	—	2.97	2.92	2.78	2.51
Ur_{236}	0.96	1.15	1.35	1.47	1.64	1.52	1.40	1.26	1.08	0.81	0.89*	1.34*	2.20*

For ions marked*, $\frac{d\alpha}{dn} > 0$ when $n = 3$.

It is obvious that if the ion source is open at $|\theta| < 6°$, then the energy of ions Ur_{235} and Ur_{238} will be noticeably different ($E_{235} > E_{238}$), which makes them to be separated easily by means of a deflecting plate.

Prof. Lange suggested the use of a cyclotron operating on multiple frequencies for the separation of isotopes of uranium. It can be easily shown that in the simplest case of a uniform magnetic field H, the necessary and sufficient condition of obtaining a pure isotope of the mass m_0 in the presence of an isotope of the mass m, using the multiple frequency k, will be:

$$kn_0 > \frac{2}{\pi\left|\frac{m}{m_0} - 1\right|}, \qquad \left(k\left|\frac{m}{m_0} - 1\right| \ll 1\right), \quad n_0 = \frac{eH^2\rho^2}{4mc^2U_0},$$

where ρ is the radius of the cyclotron chamber.

In the particular case of obtaining Ur_{235} this condition is confined to $kn > 50$, this being easily achieved. As in the cyclotrons of usual dimensions the velocities of heavy ions are smaller than those attainable in the linear accelerator, and the lifetime of ions of the mass m in the chamber is long, the space charge should be considerably larger in the cyclotron than in the linear accelerator, provided the ion currents are equal.

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BIOPHYSIK

ÜBER DIE ABSOLUTE EMPFINDLICHKEIT DES AUGES IM ULTRAVIOLETTEN UND IM SICHTBAREN SPEKTRUM

Von N. I. PINEGIN

(Vorgelegt von S. I. Wawilow, Mitglied der Akademie, den 4. XII. 1940)

Die Literatur ([1–10]) gibt uns keine bestimmte Antwort auf die Frage der Empfindlichkeit des Auges im ultravioletten Spektrum. Wir stellten uns deshalb die Aufgabe der Bestimmung der absoluten Empfindlichkeit des Auges im ultravioletten und im sichtbaren Spektrum.

Zur Monochromatisierung bedienten wir uns der zweifachen spektralen Zerlegung mittels Quarzoptik in Kombination mit Lichtfiltern zur Beseitigung des Streulichtes. Als Quelle diente uns eine Hochdruck-Quecksilber-Quarzlampe bei konstanten Brennverhältnissen. Die absolute Energieverteilung wurde gemessen mittels eines am schwarzen Körper und an Hefnerkerze geeichten Thermoelementen.

Die Versuchsperson wurde einer vorläufigen Adaptation im Dunkeln während einer Stunde unterzogen. Das Objekt wurde unter einem Gesichtswinkel von etwa 20′ betrachtet. Die Messungen der achromatischen Schwellen entsprachen dem etwa 10° von der Fovea entfernten Netzhautgebiete.

Die qualitativen Ergebnisse sind die folgenden. Untersucht wurden 30 Versuchspersonen im Alter von 15 bis 60 Jahren. Als gut sichtbar erwiesen sich Strahlungen 390, 365, 334 und 313 mμ. Als Sichtbarkeitsgrenze wurde die Wellenlänge 302 mμ ermittelt, die von Versuchspersonen im Alter von 15 bis 37 Jahren nach Dunkeladaptation wahrgenommen wurde. Strahlungen unter 302 mμ blieben unsichtbar. Dabei liess sich graue Fluoreszenz des Auges bemerken. Das Bild eines runden Beobachtungsgegenstandes erschien als ein dunkler von einem grellen farbigen Hof umgebener Fleck. Bei 302 mμ hat dieser Hof eine schwach ausgesprochene Färbung. Die Grösse des Hofes nimmt mit Abnahme der Wellenlänge zu. Das Vorhandensein dieses Hofes erklärt sich durch shlechte Fokussierung des Lichtes auf der Netzhaut infolge der chromatischen Aberration des Auges.

Nach Beseitigung der chromatischen Aberration mittels negativer Quarzlinsen verschwindet der farbige Hof, und der Beobachtungsgegenstand erscheint nun in Form einer scharf umschriebenen grellen farbigen Scheibe. Die Helligkeit des Hofes nimmt dabei zu, während seine Farbe gesättigter wird als unter den Bedingungen des defokussierten Bündels.

Die Farbe der ultravioletten Strahlungen verändert sich mit der Wellenlänge. Bei hoher Intensität erscheint die Strahlung 390 mμ Wellenlänge als violett gefärbt, ähnlich wie 404—407 mμ; 365 und 334 mμ erscheinen

der Mehrzahl der Versuchspersonen als blau gefärbt, ähnlich wie 435 mμ; 313 mμ wird von der Mehrzahl als blau gefärbt, an 491 mμ erinnernd gesehen; 302 mμ erscheint schliesslich als hell-bläulich oder grau.

Es ist zu betonen, dass unter den von uns gewählten Bedingungen sowohl normale als auch linsenlose Augen im ultravioletten Spektrum übereinstimmende Farbenempfindungen aufweisen ([11]). Bei geringer Intensität unterscheidet sich die Färbung der ultravioletten Strahlungen hinsichtlich der Sättigung von der Färbung bei hoher Intensität. An der Empfindlichkeitsschwelle wird die Färbung grau.

Bei der Wahrnehmung der ultravioletten Strahlungen durch das normale Auge handelt es sich um reelle Sichtbarkeit dieser Strahlungen, d. h. um die Empfindlichkeit der Netzhaut ihnen gegenüber, nicht aber um die Fluoreszenz der Augenmedien. Dies ergibt sich aus folgendem: 1) Bei der Ablenkung des Blickes von der Sehlinie des Objekts wird das Objekt unsichtbar, während die Fluoreszenz des Auges bestehend bleibt. 2) Nach Beseitigung der chromatischen Aberration mittels Quarzlinse lässt sich auf der Netzhaut ein deutliches Bild erreichen. 3) Strahlungen 390—302 mμ erscheinen bei hoher Intensität als gefärbt, die Fluoreszenz des Auges dagegen farblos. Das Vorhandensein von Farbenempfindungen bezeugt, dass Zapfen dabei tätig sind. 4) Bei geringer Intensität wird das Stäbchensehen wirksam ebenso, wie im sichtbaren Spektrum. Für das linsenlose Auge lässt sich die Beobachtung des Objekts bei geringer Intensität bequemer auch peripherisch durchführen ([11]).

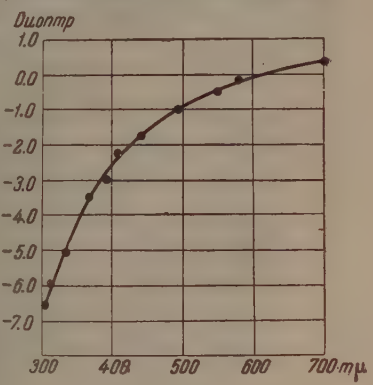

Abb. 1.

Die Bestimmung der Empfindlichkeit der Netzhaut ultravioletten Strahlungen gegenüber ist vom wesentlichen Interesse, insbesondere im Zusammenhange mit den Beobachtungen von A. G. Gaydon ([11]), dem an einem Auge die Linse entfernt wurde, und mit Versuchen von S. I. Wawilow ([12–14]). Die geringe Empfindlichkeit des Auges im ultravioletten Spektrum erklärt sich grösstenteils durch Absorption der Augenmedien ([15], [16]). Dies wird auch bestätigt durch die Beobachtungen von Gaydon, dessen Auge im Gebiete um 365 Å eine 1000 Mal höhere Empfindlichkeit aufwies als das normale Auge, bei dem also das Maximum im ultravioletten Spektrum der Grösse nach fast dasselbe war, als auch im sichtbaren Spektrum. Es sei jedoch betont, dass direkte Bestimmungen der Netzhautempfindlichkeit des linsenlosen Auges im ultravioletten Spektrum bis jetzt nicht vorliegen. Solche Bestimmungen bilden die Aufgabe weiterer Untersuchungen.

Die quantitativen Bestimmungen gestalteten sich folgendermassen. Wir bestimmten an 9 im Alter von 15 bis 37 Jahren stehenden Versuchspersonen mit normalem Gesichtssinn die absolute Schwellenempfindlichkeit des Auges im Gebiet 709—302 mμ sowohl im (achromatischen) Dämmer-, als auch im (chromatischen) Tagessehen. Da das Auge chromatische Aberration besitzt, war es notwendig den Einfluss dieser letzteren auf die spektrale Empfindlichkeit des Auges zu berücksichtigen. Die chromatische Aberration, deren Wert bei 576—579 mμ nahezu Null ist, nimmt mit abnehmender Wellenlänge zu (Abb. 1). Im Gebiet 709—302 mμ verändert sie sich, im Durchschnitt für 9 eumetropische Versuchspersonen, um 7 Dioptrien, indem sie bei 302 mμ den Wert von 6.6 Dioptrien erreicht. Im sichtbaren Spektrum (709—407 mμ) verändert sie sich nur geringfügig (um 2.61 Dioptrien). Dagegen ist ihre Veränderung im ultravioletten Spektrum (407—302 mμ) eine

sehr erhebliche, nämlich um 4.27 Dioptrien, d. h. 1.63 Mal so gross, als im sichtbaren Spektrum.

Die Ergebnisse sind in der Tabelle und Abb. 2—5 dargestellt. Auf die Ordinatenachse sind die Logarithmen der energetischen Schwellenbeleuchtung der Pupille ($\mathrm{Log}\, V_\lambda$ erg/sec. cm^2) aufgetragen. Die oberen Kurven der Abb. 2—4 geben die achromatischen, die unteren—die chromatischen Schwellen wieder. Die beiden Schwellen sind in Form von 2 Kurven dargestellt: 1) die höher liegenden Kurven V_1 und V_1', die nach Beseitigung der chromatischen Aberration gewonnen wurden, und 2) die Kurven V_2 und V_2', die beim Vorhandensein der chromatischen Aberration aufgenommen wurden.

Die Kurven V_1 und V_2 fallen bei 576—579 mμ und 546 mμ praktisch zusammen; ebenso die Kurven V_1' und V_2' bei 709—690 und 579—576 mμ, d. h. bei minimaler chromatischer Aberration. Der punktierte Teil der

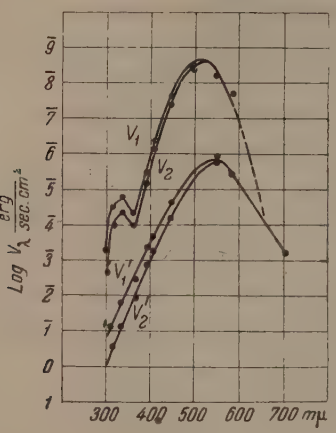

Abb. 2.

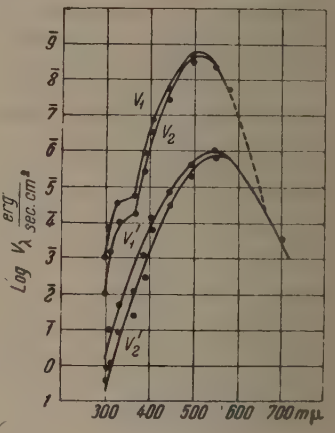

Abb. 3.

Kurven V_1 und V_2 ist durch Extrapolation gewonnen, weil im Quecksilberspektrum Linien zwischen 709—690 und 579—576 mμ fehlen, während bei 709—690 mμ der Begriff der achromatischen Schwelle unbestimmt wird, da für diese Wellenlänge sich nur die chromatische Schwelle bestimmen lässt. Deswegen ist λ=709—690 mμ als letzter Punkt nur für die Kurven V_1' und V_2' genommen. Die Kurven V_1 und V_2 haben im sichtbaren Spektrum ein Maximum bei 491 mμ, während das Maximum der Kurven V_1' und V_2' bei 546 mμ liegt. Eine exaktere Bestimmung der Lage der Maxima erwies sich als unmöglich, insofern entsprechende Linien im Quecksilberspektrum fehlen.

In Abb. 4 sind die Maxima der Kurven anschaulichkeitshalber auf demselben Niveau dargestellt. Die Lage der Maxima und der allgemeine Charakter der Kurven spricht dafür, dass wir es hier mit Kurven der absoluten Schwellenempfindlichkeit des Auges im Dämmerungs- und Tagessehen zu tun haben. Im sichtbaren Spektrum zeigen sie eine durchaus befriedigende Übereinstimmung mit der Dämmerungskurve nach Hecht ([17]) und der Tageskurve nach Gibson-Tyndall ([18]), wenn diese im entsprechendem Masstab dargestellt werden (siehe Abb. 5, in welcher die Punkte der Kurven von Hecht und Gibson-Tyndall als Kreise aufgetragen sind). Im ultravioletten Spektrum ist der Verlauf der Kurven ein wesentlich anderer.

Die chromatische Empfindlichkeit zeigt mit abnehmender Wellenlänge bis zu 302 mμ gesetzmässige Abnahme (Abb. 2—5). Die achromatische Empfindlichkeit nimmt mit abnehmender Wellenlänge zunächst ebenfalls ab.

bekommt aber nachher ein zweites Maximum oder eine Abflachung, worauf hin sie sehr scharf abfällt.

Das Maximum der achromatischen Empfindlichkeit fällt auf 334 mμ. Es wurde gewonnen an 4 Versuchspersonen (Tabelle, 1-te Gruppe, und Abb. 2). Die Abflachung der Kurven der achromatischen Schwelle fällt auf das Gebiet 365—334 mμ. Sie wurde ebenfalls an 4 Versuchspersonen gewonnen (Tabelle, 2-te Gruppe, und Abb. 3).

Nur bei einer von den 9 Versuchspersonen liess sich eine gesetzmässige Abnahme der achromatischen Empfindlichkeit mit abnehmender Wellenlänge feststellen. Der Vergleich des Maximums der achromatischen Empfindlichkeit im Ultraviolett mit entsprechendem Maximum im sichtbaren Spektrum zeigt, dass die Empfindlichkeit für 491 mμ (einer Wellenlänge, die sich dem Maximum der Dämmerungskurve nähert) 5500—9000 Mal so gross ist, als für 334 mμ (nach Beseitigung der

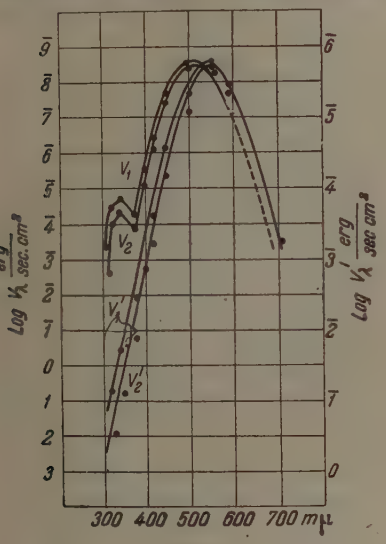

Abb. 4.

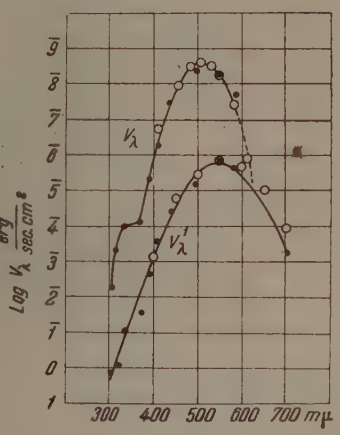

Abb. 5.

chromatischen Aberration und beim Vorhandensein dieser letzten). Maximale achromatische Empfindlichkeit im ultravioletten Spektrum wird bei jungen Versuchspersonen (im Alter von 15—19 Jahren) beobachtet. Dabei ist, anscheinend, die Pigmentation der Iris von Bedeutung: bei Dunkelpigmentierten ist der relative Wert des Maximums V_{365}/V_{334} 2—2.5 Mal so gross, als bei Hellpigmentierten in entsprechend gleichem Alter.

Das Vorhandensein eines Maximums der achromatischen Empfindlichkeit im ultravioletten Spektrum bringt uns auf den Gedanken einer maximalen Durchlässigkeit der Linse in diesem Gebiete. Auch die Möglichkeit der hohen Empfindlichkeit der Netzhaut an sich ist nicht ausgeschlossen, umsomehr als es gelungen ist sie im Ultraviolett (für 3800 Å) zu konstatieren ([11–14]).

Die spektrale Empfindlichkeit des Auges nimmt unter dem Einfluss der chromatischen Aberration ab. Mit Zunehmen der chromatischen Aberration wird diese Abnahme immer bedeutender; ihren Ausdruck findet sie in Form des Auseinandergehens sowohl der Kurven V_1 und V_2, als auch der Kurven V_1' und V_2' (Abb. 1—4). Die chromatische Empfindlichkeit nimmt dabei stärker ab, als die achromatische.

Von wesentlichem Interesse ist die Frage nach der Grösse der absoluten und relativen Schwellen. Nachstehend seien die Durchschnittswerte für

Achromatische und chromatische Schwelle im ultravioletten und sichtbaren Spektrum (Beleuchtung der Pupille $V_\lambda \frac{\text{erg}}{\text{sec. cm}^2}$) (Mittelswerte für 2 Gruppen von Versuchspersonen)

λ mμ \ V_λ	1-te Gruppe				2-te Gruppe			
	V_1	V_2	V_1'	V_2'	V_1	V_2	V_1'	V_2'
302	4.79×10^{-4}	2.24×10^{-3}	—	—	1.03×10^{-3}	1.06×10^{-3}	1.27	3.04
313	3.58×10^{-5}	1.13×10^{-4}	8.24×10^{-2}	2.93×10^{-1}	1.73×10^{-4}	7.29×10^{-4}	1.21×10^{-1}	1.07
334	2.11×10^{-5}	4.94×10^{-5}	1.89×10^{-3}	7.7×10^{-2}	3.17×10^{-5}	1.18×10^{-4}	2.25×10^{-2}	1.32×10^{-1}
365	5.65×10^{-5}	1.36×10^{-4}	3.86×10^{-3}	1.4×10^{-2}	1.96×10^{-5}	6.34×10^{-5}	9.45×10^{-3}	3.92×10^{-2}
390	3.25×10^{-6}	8.62×10^{-6}	4.75×10^{-4}	1.42×10^{-3}	1.31×10^{-6}	3.78×10^{-6}	9.24×10^{-4}	3.47×10^{-3}
404—407	3.97×10^{-7}	7.16×10^{-7}	2.46×10^{-4}	6.32×10^{-4}	1.73×10^{-7}	3.35×10^{-7}	7.35×10^{-5}	1.8×10^{-4}
435	2.31×10^{-8}	3.75×10^{-8}	2.78×10^{-5}	7.27×10^{-5}	2.19×10^{-8}	3.83×10^{-8}	1.54×10^{-5}	3.07×10^{-5}
491	3.08×10^{-9}	4.53×10^{-9}	4.76×10^{-6}	9.01×10^{-6}	2.45×10^{-9}	3.41×10^{-9}	2.72×10^{-6}	5.16×10^{-6}
546	6.22×10^{-9}	5.88×10^{-9}	1.74×10^{-6}	1.97×10^{-6}	4.49×10^{-9}	4.61×10^{-9}	1.12×10^{-6}	1.64×10^{-6}
526—579	2.24×10^{-8}	2.24×10^{-8}	3.83×10^{-6}	3.83×10^{-6}	2.02×10^{-8}	2.19×10^{-8}	2.27×10^{-6}	2.27×10^{-6}
690—709	—	—	6.38×10^{-4}	7.55×10^{-4}	—	—	3.47×10^{-4}	3.69×10^{-4}

9 Versuchspersonen angeführt. Für die Wellenlänge 491 mμ, die sich dem Maximum der Dämmerungskurve nähert, beträgt die achromatische Schwelle 4×10^{-9} erg/sec. cm², oder etwa 1000 Quanten. Der Schwellenwert des Maximums der Dämmerungskurve sollte natürlich geringer sein, als die angeführte Schwelle für 491 mμ. Nach v. Kries [19] beträgt für 507 mμ die Schwellenenergie 2.6×10^{-10} erg/sec., nach Russel [20] 7.7×10^{-10} erg/sec. Die Schwelle für 491 mμ übertrifft also nach unseren Bestimmungen die von Russel und v. Kries angegebenen Schwellenwert für 507 mμ nur um 5—15 Mal.

Für 365 mμ beträgt die Schwelle nach Beseitigung der chromatischen Aberration $V_1=3.45\times10^{-5}$ erg/sec. cm², bei chromatischer Aberration dagegen $V_2=8.99\times10^{-5}$ erg/sec. cm². Die erste übertrifft den Schwellenwert für 491 mμ 10700 Mal, der zweite—20000 Mal, das entsprechende Mittel aus den beiden Werten (6.22×10^{-5} erg/sec. cm²)—15500 Mal.

Die Empfindlichkeit des linsenlosen Auges war bei Gaydon [11] auf dem Gebiete 365 mμ 1000 Mal grösser als diejenige des normalen Auges. Das von Gaydon gefundene Verhältnis erweist sich, im Vergleich mit unseren Durchschnittsdaten, als 10—20 Mal zu klein. Es zeigt jedoch Übereinstimmung mit den von uns bei einer Versuchsperson mit relativ herabgesetztem Maximum der Dämmerungskurve und erhöhter Empfindlichkeit für 365 mμ erhaltenen Resultaten. Für eine gewisse Kategorie von Versuchspersonen scheint also die Angabe von Gaydon ihre Geltung zu behalten.

Für 334 mμ ist $V_1=3.75\times10^{-5}$ und $V_2=9.85\times10^{-5}$ erg/sec. cm². Der erste Schwellenwert ist 11600 Mal so gross wie die Schwelle für 491 mμ, der zweite—22000 Mal so gross. Für 313 mμ ist $V_1=1.46\times10^{-4}$ und $V_2=5.35\times10^{-4}$ erg/sec. cm². Ihre relativen Werte sind 45000 und 118000. Für 302 mμ ist schliess-

lich $V_1 = 7.55 \times 10^{-4}$ und $V_2 = 5.81 \times 10^{-3}$ erg/sec. cm². Die relativen Werte sind: 234000 und 1285000.

Für 546 mμ, die sich dem Maximum der Tageskurve nähert, beträgt die chromatische Schwelle 1.51×10^{-6} erg/sec. cm². Sie übertrifft die achromatische Schwelle für 491 mμ um 375 Mal. Für 365 mμ ist die Schwelle nach Beseitigung der chromatischen Aberration $V_1' = 6.69 \times 10^{-3}$ erg/sec. cm², beim Vorhandensein dieser letzten ist $V_2' = 2.87 \times 10^{-2}$ erg/sec. cm². Der erste Wert übertrifft die Schwelle für 546 mμ 5000 Mal, der zweite—17000 Mal.

Für 334 mμ ist $V_1' = 2.13 \times 10^{-2}$ und $V_2' = 1.15 \times 10^{-1}$ erg/sec. cm². Die relativen Werte sind 16000 und 68000. Für 313 mμ ist $V_1' = 8.86 \times 10^{-2}$ und $V_2' = 8.77 \times 10^{-1}$ erg/sec. cm². Relative Werte—66000—519000. Für 302 mμ schliesslich ist $V_1' = 8.47 \times 10^{-1}$ und $V_2' = 1.545$ erg/sec. cm². Relative Werte—632000 und 914000.

Wir sehen somit, dass im ultravioletten Spektrum die spektrale Empfindlichkeit des Auges im Vergleich mit dem entsprechenden Maximum im sichtbaren Spektrum mehrere Zehn- und Hunderttausend Mal geringer ist.

S. I. Wawilow, Mitglied der Akademie, M. M. Gurewitsch und L. M. Gassowsky muss ich hier für wertvolle Ratschläge und Hinweise meinen Dank aussprechen.

Staatliches Optisches Institut.
Leningrad.

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Übersetzt von W. Beloussow.

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BIOPHYSIQUE

L'INFLUENCE DES EXPÉRIENCES RÉPÉTÉES DE L'ABAISSEMENT DE LA PRESSION ATMOSPHÉRIQUE SUR LA VARIATION DE LA SENSIBILITÉ DE L'OEIL AU COURS DE LA VISION PÉRIPHÉRIQUE

Par T. N. TCHIJEVSKAYA

(Présenté par P. P. Lasareff, de l'Académie, le 24. IX. 1940)

1. Le but et le caractère de la recherche. Dans l'étude précédente, effectuée en commun par P. P. Lasareff, de l'Académie, et par l'auteur (1), il a été montré que les ascensions des montagnes (Aï-Petry, 1180 m; Atchichko, 1880 m) en été ont toujours été suivies d'augmentation de la sensibilité limite E_0 au cours de la vision périphérique. Puisque nos observations suivantes nous ont montré l'influence de la température de l'air environnant sur la grandeur E_0, nous crûmes nécessaire d'entreprendre l'étude de l'influence de l'abaissement de la pression sur l'adaptation visuelle périphérique en cas de température constante. C'est précisément ceci qui fait le but de la présente recherche, qui nous a été suggérée par P. P. Lasareff. Cette question est intéressante non seulement au point de vue physiologique et biophysique, mais elle a aussi de l'importance pour la pratique aéronautique. Les expériences ont été effectuées en partie dans la chambre barométrique de l'Institut I. P. Pavloff de la Médecine aérienne (1936), et en majeur partie, dans la chambre barométrique du Laboratoire central de la Médecine aérienne de l'Aviation civile (1938, 1939, 1940).

Les expériences ont eu le caractère de longues épreuves; la durée moyenne de l'expérience dans la chambre barométrique a été de 6 heures (9 heures au plus, 4 heures au moins). Au cours de l'épreuve dans la chambre barométrique la première pression limite atteignait 354 mm Hg, ce qui correspond à l'altitude de 6000 m. Toutes les observations ont été effectuées à la température 20—26° C. Pour ces petites variations de température on n'observait pas de changement sensible de E_0. La chambre barométrique a été continuellement ventilée. Le bruit du moteur* a été toujours un excitateur supplémentaire, ce qui a eu lieu dans les expériences d'autres auteurs. L'adaptation a été mesurée par l'adaptomètre de P. P. Lasareff (2).

Le nombre des expériences effectuées était 150, dans lesquelles ont pris part 21 personnes (11 femmes et 10 hommes) en grande partie agées de 18 à 26 ans. A l'exception de 2 personnes, les autres ont été en bonne santé, bien entraînées à l'adaptation, et non entraînées dans la chambre barométrique.

2. Méthode de l'étude. On déterminait la sensibilité limite E_0 et en certains cas α_3, qui est égal au coefficient de vitesse de la restauration du pourpre visuel dans l'obscurité. La détermination de ces grandeurs se faisait d'après la formule de P. P. Lasareff (3): $E_0 = E_0(1 - \gamma e^{-\alpha_3 t})$,

* La mise en marche du moteur était effectuée au cours de toutes les expériences aussi bien sur la terre (300 m) à la pression normale, qu'à la pression plus basse. Par conséquent, le fond sonore ne variait pas.

où E est la sensibilité à l'instant donné t, γ—une fraction régulière, e—la base du logarithme naturel. D'après cette formule on trouvait par calcul la valeur expérimentale de la sensibilité maximum limite E_0; tandis que α_3 l'on définissait par la méthode graphique de Gambourzeva ([4]).

Les expériences étaient faites par deux méthodes. Dans la première série la pression atteignait rapidement la valeur donnée p, correspondant à l'altitude h. On étudiait la sensibilité limite E_0 à la pression constante et, lorsque cela était possible, on trouvait également α_3. Par conséquent, au cours d'une expérience on n'étudiait l'influence que d'une seule altitude. Les expériences furent répétées avec les mêmes épreuves et les mêmes altitudes.

Le changement de la pression atmosphérique à partir de celle de la terre (300 m)* jusqu'à la valeur voulue, correspondant à l'altitude fictive, se faisait généralement en 30 min. Les études de cette série d'expériences ont été faites avec et sans oxygène. Dans la seconde série les mesures aux altitudes fictives différentes (les pressions p diverses) étaient prises au cours d'une seule expérience (élévation par grades successifs). Après une détermination préliminaire de la sensibilité limite E_0 au niveau de la terre, on effectuait une série d'ascensions progressives, et l'on trouvait les valeurs correspondantes de la sensibilité limite. La vitesse de changement de la pression était de 1000 m de l'altitude fictive en 5 min. La durée de l'arrêt à l'altitude donnée était en moyenne de 30 min. Ces expériences étaient également répétées et se faisaient sans aspiration supplémentaire de l'oxygène.

3. Résultats. (I). Les expériences avec des personnes ayant subi l'influence peu fréquente, mais prolongée de la basse pression, montrent, que la réaction des diverses gens à la baisse de pression varie beaucoup. La majeur partie (près de 90%) de personnes observées aux petites altitudes (1500—3000 m) montre pendant trois ou quatre premières expériences l'augmentation de la sensibilité de la vision périphérique. Même au cas, où pendant la première expérience on observait la baisse de la sensibilité, les expériences suivantes, faites un ou deux jours après, produisaient infailliblement l'augmentation de E_0. Aux altitudes h moyennes (3000—4000 m) le nombre de personnes offrant une augmentation de la sensibilité se réduit lorsque la pression baisse, progressivement de 67 à 40%. Aux altitudes supérieures à 5000 m on n'observe pas d'augmentation de la sensibilité; bien au contraire, la sensibilité diminue. La pression correspondant à 1000 m ne produit aucun effet.

(II). Les expériences répétées (résultats des ascensions multiples), où l'on étudiait l'influence de la basse pression p, ont été faites avec quelques personnes pendant 7 mois d'ascensions constantes. Les intervalles entre deux expériences successives variaient de 1 à 5 jours. Après une série d'expériences à petites altitudes fictives, l'influence de h sur E_0 disparaît de façon que E_0 se trouve la même sur le niveau de la terre et à l'altitude de 3000 m. Un grand nombre d'expériences sur un riche matériel a donné de résultats congruents. Nous donnons plus bas une série d'expériences avec une personne (E. P. K. agée de 30 ans) observée aux altitudes différentes (tableau 1).

Tableau 1

	I série		II série		III série	
Altitude h	300 m	1500 m	300 m	2000 m	300 m	3000 m
E_0	54.5	55.5	46.0	46.8	40.0	39.0

* La mise en marche du moteur produisait la raréfaction de l'air correspondant à l'altitude de 300 m, ce qui a été pris pour la pression au niveau de la terre.

Aux grandes altitudes fictives, à partir de 5000 m, l'influence de la basse pression sur E_0 en cas des expériences répétées diminue, mais ne disparaît pas (tableau 2).

Tableau 2

Sujet observé	Première expérience		Dernière, huitième expérience		Nombre total d'expériences
Altitude h	300 m	5000 m	300 m	5000 m	
(E.P.K.) E_0	50.6	16.9	35.0	27.4	8
(S.M.M.) E_0	30.0	22.2	28.1	22.6	10
(I.O.S.) E_0	24.1	17.3	26.3	23.3	6
Altitude h	300 m	6000 m	300 m	6000 m	
(S.M.M.) E_0	32.9	10.3	28.1	18.2	3
(I.O.S.) E_0	26.0	10.1	30.4	16.1	3

Le nombre d'expériences nécessaire pour faire disparaître l'influence de h sur E_0 est d'autant plus grand, que la pression est plus petite. Il est tout naturel, que diverses personnes observées exigent des degrés différents de l'influence.

(III). Au cours de l'étude avec l'ascension par grades successifs aux altitudes fictives croissantes après quelques expériences on observait un maximum de sensibilité correspondant à l'altitude de 1500—3000 m (fig. 1, *A*). Au cours des expériences le maximum *M* baissait et disparaissait (fig. 1, *B* et *C*). Aux grandes altitudes, après de longues expériences répétées, on obtenait une diminution de sensibilité par rapport aux valeurs trouvées dans les premières expériences (fig. 1, *A*, K_1; fig. 1, *B*, K_2; fig. 1, *C*, K_3). Ce phénomène se manifeste le plus clairement en cas des expériences fréquemment répétées comprenant un retour dans la chambre barométrique de 6 à 9 heures. L'interruption de plusieurs semaines (par exemple, du 10 février au 18 mars) a causé la réapparition du maximum (comp. fig. 1, *C* et *D*).

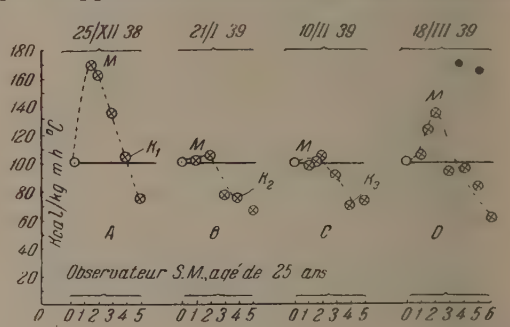

Fig. 1.

(IV). L'aspiration de l'oxygène élimine totalement, jusqu'à l'altitude de 6000 m, l'influence de h sur E_0 et sur α_3. On a fait 30 expériences avec 7 personnes. Les expériences montrent, que l'organisme sain s'adopte, au point de vue de la sensibilité visuelle périphérique, aux conditions de la dépression (en moyenne jusqu'à l'altitude 3000 m comprise).

Je tiens à exprimer ma reconnaissance à P. P. Lasareff, pour l'objet et la direction de l'étude et au prof. V. V. Streltsoff pour son aide dans les expériences.

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Laboratoire Central de la Médecine Aérienne de l'Aviation Civile.

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BIOPHYSIQUE

SUR LES BIOCOURANTS D'EXCITATION LORS DES CONTRACTIONS RHYTHMIQUES DES MUSCLES SQUELETTIQUES D'UNE GRENOUILLE

Par N. N. DZIDZICHVILI et G. G. JAURE

(Présenté par P. P. Lasareff, de l'Académie, le 24. IX. 1940)

J. Loeb (1) a montré qu'un muscle isolé d'une grenouille, plongé dans une solution des électrolytes monovalents, commence à se contracter d'une façon rhythmique sous l'influence des ions excitateurs de potassium, de sodium et de lithium. Dans certaines conditions on peut obtenir un rhythme assez réglé (2). Ces contractions rhythmiques étant enregistrées sur un miogramme font voir un amortissement qui obéit à la loi trouvée par P. P. Lasareff (3).

P. P. Lasareff nous a donné l'idée d'entreprendre l'étude des biocourants d'excitation, qui accompagnent les contractions rhythmiques d'un muscle squelettique d'une grenouille. Sur un filme photographique l'on enregistrait simultanément les contractions rhythmiques du muscle et les variations du potentiel électrique du muscle à l'état d'excitation pendant la période de contraction. Les variations du potentiel ont été enregistrées par un galvanomètre Boullit à corde, utilisé en électrocardiographie.

Sur la table de l'électrocardiographe on installait un support spécial, destiné à la suspension du muscle et fixant les électrodes, qui conduisent les biocourants d'excitation du muscle vers la corde du galvanomètre. Le muscle (m. gastrocnemius), lié, après être isolé, à la partie inférieure de la cuisse, était suspendu sur le support par un vis de serrage, fixant le reste du fémur. A l'extrémité libre du muscle, c'est-à-dire au tendon d'Achille, on fixait un fil, lié à l'intermédiaire d'une poulie au levier d'un miographe, se terminant par un stylet inscripteur. Ce dernier était placé devant la fente de la chambre de l'électrocardiographe de manière que son ombre se place à côté de celle de la corde du galvanomètre. On piquait dans le muscle deux électrodes non polarisant en argent, évacuant les courants naissants vers la corde. Les expériences ont été effectuées aux mois de mars et d'avril, c'est-à-dire pendant les mois les plus favorables pour obtenir les contractions rhythmiques.

Les contractions rhythmiques étaient produites par des gouttes d'une solution de l'électrolyte. On laissait le liquide s'égoutter jusqu'au moment où apparaissaient les contractions rhythmiques, et l'on recommencait aussitôt que ces dernières cessaient. La solution saline était composée en rapport suivant des ions excitateurs et réprimants: 75 cm^3 $\frac{m}{1}$ NaCl + 1 cm^3 $\frac{m}{1}$ $CaCl_2$.

Fig. 1 présente un des enregistrements caractéristiques de contractions rhythmiques du muscle. On voit en bas les courbes des contractions distinctes du muscle, se répétant de la façon presque périodique, avec l'intervalle entre

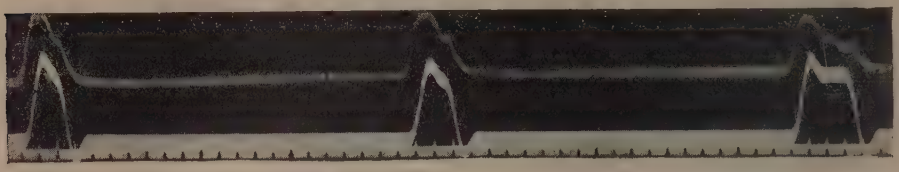

Fig. 1. Miogramme (courbe inférieure nette) et électromiogramme (courbe supérieure) dé m. gastrocnemii d'une grenouille, lors d'une excitation des contractions musculaires rhythmiques. L'électromiogramme montre de grandes oscillations résultant de l'oscillation à deux phases, que l'on peut étudier à l'aide de la loupe. L'inscription du temps se faisait avec une montre de Jaquet 0.2 sec.

deux contractions successives du muscle voisin de 4 secondes. Les contractions musculaires font voir, sur la grande partie du miogramme, un amortissement caractéristique. Dans la partie supérieure de la fig. 1 sont simultanément enregistrées les contractions du muscle et la variation de son potentiel électrique. On voit que la déviation de la corde du galvanomètre, pour ainsi

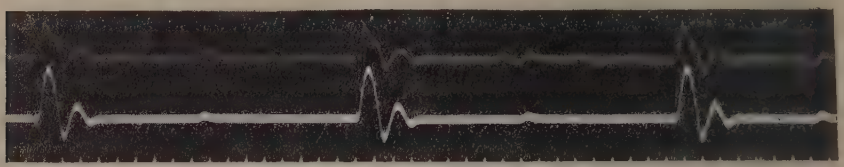

Fig. 2. L'effet des chocs d'induction après le traitement du muscle par une solution $\frac{m}{1}$NaCl 75.0 + $\frac{m}{1}$ $CaCl_2$ 1.0.

dire, imite le mouvement du levier du miographe. Les grandes oscillations, répétant sur la fig. 1 celles des contractions musculaires, subissent de même des amortissements analogues.

La marche de la courbe du potentiel ne concorde pas avec les biocourants d'excitation enregistrés en cas d'une contraction isotonique du muscle. Les

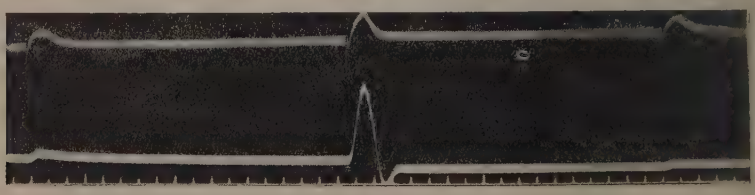

Fig. 3. Les contractions rhythmiques de m. sartorii d'une grenouille. Les électrodes sont piqués dans la partie riche de terminaisons nerveuses.

expériences multiples, qui nous ont muni toute une série d'enregistrements, montrent la constance des phénomènes présentés sur la fig. 1. L'expérience a été ensuite effectuée dans les conditions isométriques. L'enregistrement des biocourants d'excitation, correspondant aux contractions rhythmiques du muscle fixé sur le support de la façon isométrique, montre, que la courbe

de variation du potentiel a le même caractère, que celle de la fig. 1. Par conséquent, la forme de la courbe obtenue de variation du potentiel d'un muscle, se contractant d'une manière rhythmique, ne dépend évidemment pas de la position des électrodes lors de la contraction.

Il a été tout naturel de supposer que l'action même de la solution saline produit une certaine influence sur le muscle, de même que sur le caractère de son excitation. Dans la série suivante d'expériences nous avons essayé d'étudier le caractère des biocourants d'excitation dans les muscles traités avec les mêmes solutions salines, mais apparaissant non pendant une contraction spontanée du muscle, mais au cours de sa contraction, due à une excitation distincte d'induction. Afin d'éclaircir cette question, nous avons excité, par des chocs separés de l'ouverture du circuit, n. ischiadicus d'une préparation neuro-musculaire isolée de m. gastrocnemii. L'on enregistrait simultanément l'effet de la contraction et de l'excitation. En même temps on enregistrait l'effet généralement observé. Ensuite le même muscle subissait le traitement avec une solution saline. Lorsque les contractions rhythmiques, dues à l'action de la solution, cessaient, l'on excitait la même région de n. ischiadici par des chocs d'induction de la même intensité, et l'on enregistrait de nouveau les effets électriques et mécaniques de la contraction du muscle. Comme l'on voit des données enregistrées au cours de cette partie d'expériences (fig. 2), l'effet électrique change considérablement.

La comparaison des miogrammes et des électrogrammes d'une préparation normale et d'une autre, traitée par une solution saline, montre, que dans les deux cas l'effet électrique précède l'effet mécanique. Mais tandis qu'en premier cas l'effet électrique cesse rapidement lors du commencement de l'effet mécanique, dans la deuxième partie de l'expérience, c'est-à-dire après le traitement par une solution saline, l'effet électrique, bien qu'installé avant la contraction, possède un caractère plus durable et se passe presque parallèlement à l'effet mécanique. En général, les effets électriques, dus au muscle qui se contracte rhythmiquement, et les effets des contractions produites par une excitation d'induction par un nerf, se distinguent les uns des autres, ce que l'on voit si l'on compare les fig. 1 et 2.

Il a été naturel de supposer, que cette distinction est due à la cause suivante: en cas des contractions spontanées du muscle, nous enregistrons le changement du potentiel électrique des fibres mêmes des muscles; dans l'autre cas s'intercale aussi l'effet nerveux, car l'excitation du tissu musculaire est produite par l'intermédiaire des fibres nerveuses, excitées à leur tour par des chocs d'induction. Afin de vérifier cette hypothèse nous avons decidé d'enregistrer l'effet électrique dans les parties du muscle plus riches des terminations nerveuses lors des contractions rhythmiques. L'objet bien répondant à cette condition est, à notre vue, m. sartorius, certaines régions duquel sont richement pourvues de terminaisons nerveuses. Dans nos expériences nous avons évacué les biocourants d'excitation de ces parties du m. sartorius lors des contractions rhythmiques. Les contractions rhythmiques spontanées étaient produites de la même façon, que dans le cas de m. gastrocnemii.

Fig. 3 montre que l'effet électrique des contractions rhythmiques de m. sartorii se distingue de l'effet analogue de m. gastrocnemii. L'enregistrement du potentiel électrique manifeste une déviation nette de la corde avant le début de la montée durable. Le rapprochement de caractères des électrogrammes des contractions spontanées de m. sartorii et de celles produites par le nerf de m. gastrocnemii, ayant subi le traitement d'une solution saline, permet de croire que l'hypothèse émise plus haut se confirme. Il reste encore à expliquer l'effet électrique durable, copiant, pour ainsi dire, l'enregistrement de l'effet mécanique, lors de la contraction rhythmique d'un muscle.

A notre avis, ces grandes oscillations doivent se composer de courtes décharges électriques séparées, comme cela a lieu en cas de l'action synchrone des fibres nerveuses (Adrian). En analysant à l'aide d'une loupe nos courbes, on peut voir que l'effet électrique durable, pendant les contractions spontanées du muscle, se compose de courtes impulsions separées. Mais il nous reste encore inconnu, de quoi dépend le caractère général de l'électrogramme, à savoir, pourquoi l'effet électrique a une courbe qui croît tout comme celle de la contraction musculaire.

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1941. Volume XXX, № 3

CHEMISTRY

THERMAL CONDUCTIVITY OF SILICOCHROME

By N. N. KURNAKOV

(Communicated by N. S. Kurnakov, Member of the Academy, 17. X. 1940)

The thermal conductivity of silicochrome (an alloy smelted at the Cheliabinsk ferrous alloy plant for the production of low-carbon grade of ferrochrome after Gin's method) was determined after Jakob's method with an apparatus designed specially for the purpose of measuring the thermal conductivity of ferrous alloys. This apparatus has already been described by us (1). The measurements were made on samples of Cheliabinsk silicochrome and synthetic alloys. Analyses of these samples are given in the table.

The samples were ground on a carborundum polishing disc into a form of flat washers with two parallel faces. These washers were 20 mm and more in diameter, and 5 to 30 mm thick. The hardness and brittleness of silicochrome made the preparation of the samples quite difficult. The thermal conductivity of silicochrome was measured for the temperature interval 40°—50° C. The results are given in the table.

Thermal Conductivity of Silicochrome

No. of alloy	% Si	% Cr	% Fe	Cal./m hr °C
T-26	27.89	47.30	24.06	46.6
528	31.7	43.52	24.75	52.5
497	32.30	44.52	23.08	51.0
527	32.33	42.81	24.75	50.0
515	34.94	40.78	23.77	49.5
T-42	41.5	—	—	46.3
T-47	46.55	28.35	24.44	43.7
T-49	48.10	25.50	26.13	45.1
T-55	53.61	17.95	27.31	39.5
T-60	60.27	14.45	24.83	30.8
T-65	62.10	9.94	27.40	33.1
T-72	67.9	3.77	27.74	31.5

Measurements of the thermal conductivity show that the specific heat conductivity of Cheliabinsk silicochrome is 30—54 Cal./m hr °C. There is a singular point on the specific heat conductivity curve of silicochrome (Fig. 1) which corresponds to an alloy of the composition (Cr, Fe) Si, i. e. chromium monosilicide CrSi, in which part of the chromium is displaced by iron. The silicon content in this alloy is about 35%.

Besides, the curve has a weakly defined kink corresponding to the composition (Cr, Fe) Si_2 which is chromium bisilicide $CrSi_2$, in which part of the chromium is displaced by iron. The silicon content in this alloy is about 52%.

Determination of the thermal conductivity of silicochrome offers further proof of the fact that the phase of the composition (Cr, Fe) Si, mentioned by Andersen and Jette (2) and studied crystallographically by us (3), really

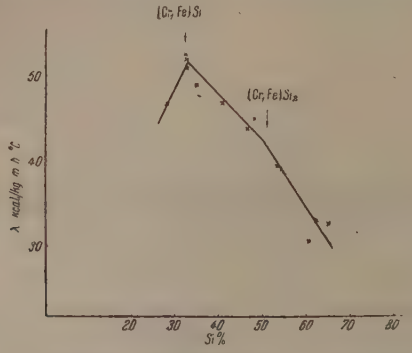

Fig. 1. Thermal conductivity of silicochrome.

exists in the ternary system Cr—Si—Fe. This phase crystallizes in tetrahedrons.

The ternary compound of the composition (Cr, Fe) Si_2 corresponds to chromium bisilicide $CrSi_2$ which was studied by us (4) in the double system Cr—Si.

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CHEMISTRY

ON THE INTRAMOLECULAR MIGRATIONS OF HYDROGEN AND RADICALS IN ORGANIC REACTIONS

By E. A. ŠILOV

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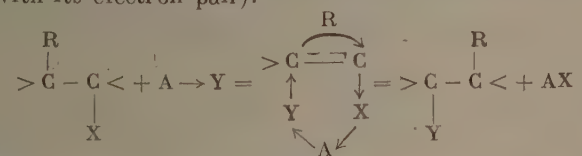
The modern classification of elementary organic reactions in its different varieties discerns radical, ionic and ionoid processes (1) designated as electrophile or as nucleophile ones, according to the sign of electroaffinity of the agent bringing about the reaction (2). The diverse organic reactions of substitution, addition and elimination can be brought down in this way to several principal species.

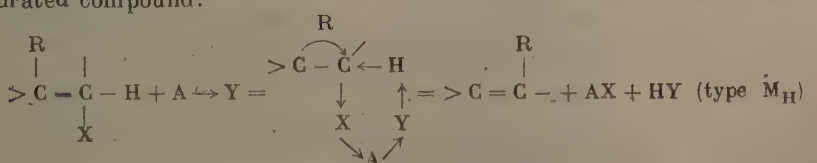
In connexion with the studies of the course of rearrangements I see the necessity to introduce as a particular form a specific and general mechanism which may be conveniently named the mechanism of migration. This mode of reaction consists in the transition of hydrogen or of radical to the adjoining carbon atom under the formation of an intermediate three-member ring transition complex.

The reactions which proceed according to the migration mechanism can be represented by the following scheme (the arrows indicate the direction of the electron shift, and the symbol $\overset{R}{\frown}$ designates the transfer of the radical R together with its electron pair):



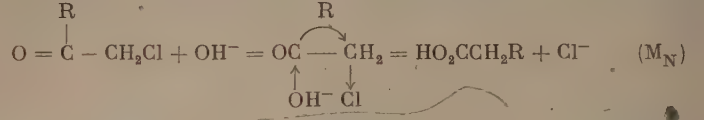
The reaction can be initiated by the electrophile (type M_E) or by the nucleophile (type M_N) affinity of the molecule AY (or by both). The molecules of the solvent or of the catalyst may participate in the structure of the active complex. On the other hand, the form of the complex may be simplified, if one of the ions A⟶Y takes no part in the active complex.

If the carbon atom X—is connected with a hydrogen atom, the reaction can proceed according to the migration scheme M_H with the formation of an unsaturated compound:

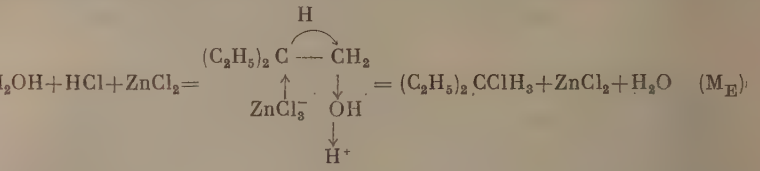


Examples of the application of the migration schemes can be found in many reactions. I have selected a few cases to demonstrate that common and typical functional reactions are repeated in the migration mechanisms.

1. Replacement of Chlorine by the Hydroxyl Group. The migration substitution takes place in the Favorsky's rearrangement ([3]):

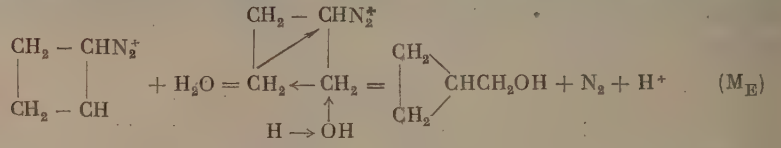


2. Replacement of the Hydroxyl Group by a Halogen. Several isomers* of the «normal» reaction product are formed when hydrogen chloride reacts with primary alcohols ([4]) in the presence of zinc chloride. For instance:

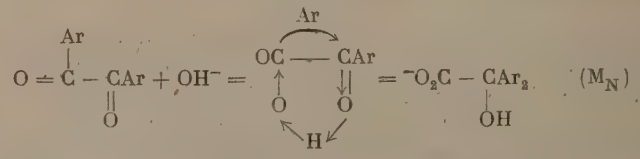


3. Replacement of the Aminogroup by the Hydroxyl under the Action of Nitrous Acid. The rearrangements during the reaction of primary amines with nitrous acid are very widespread. All these cases can be expressed by the migration schemes, if one assumes that under the action of nitrous acid on amines diazonium salts are formed first as intermediate products. The migration of hydrogen takes place in the decomposition of an aqueous solution of *n*-propyldiazonium with the formation of isopropyl alcohol ([5]); the migration of the methyl radical has been observed in the decomposition of tert. butylmethyldiazonium ([6]).

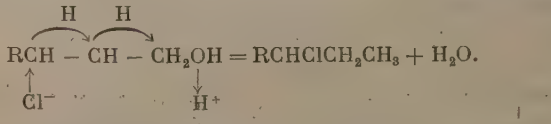
The reaction of the contraction or of the expansion of the rings of isocyclic amines, discovered by Demianov ([7]), obeys likewise the general scheme:



4. Addition of Water (benzilic acid rearrangement) ([8]):

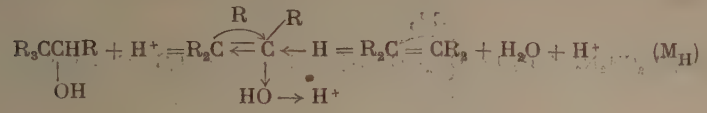


* The structures of some of the isomers seem to indicate the possibility of double migrations according to the scheme



It is however not excluded that in such cases the reaction proceeds through the formation of many consecutive compounds.

5. Elimination of Water (retropinacol rearrangement):



The examples cited above show that typical reactions of substitution, addition and elimination can proceed according to the migration mechanism. Many rearrangements follow this course (in particular, the rearrangements of Hofman, Beckman, Lossen, Curtius, Wagner, the pinacol and semipinacol, the formation of β-substituted pyridines from pyrrols, and others). Of course, the rearrangements can proceed not only through the migration mechanism, but through an intermolecular exchange of atoms with auxiliary molecules (solvents or catalysts).

It is very probable that the migrating radical is not removed from the molecule, but remains at the moment of migration in simultaneous connexion with the two neighbouring atoms. Two facts are especially demonstrative. 1) No by-products of the rearrangement reactions are observed, which may be ascribed to an intermediate existence of R as a free radical or an ion. 2) The migrating radical retains its configuration during the rearrangement ([9]).

Some theoreticians assume the formation of true C-ions during the rearrangements ([10]). To my opinion, such a case is possible, but no more obligatory in migration reactions than in the reactions without rearrangements. It is obvious that the group X is easier removed and the radical R may migrate more readily, if the adjoining atom C is exposed to the electron pressure of Y^-.

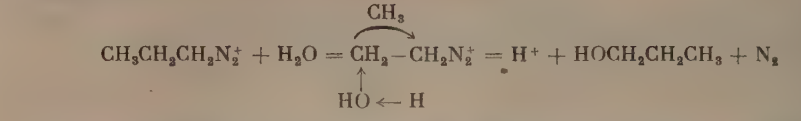
The form of the complex, assuming a simultaneous momentary connexion of the carbon atom with five different groups, finds an analogy in the current concept of the form of the complex in the reactions of the Walden inversion ([11]). This analogy is continued in the retaining of the optical activity of the carbon atom connected with the migrating radical. Wallis and Bowman obtained dextro-rotatory 2-methyl-1-phenyl-2-chlorobutan through the reaction of thionyl chloride with laevo-rotatory 2-methyl-2-phenylbutanol-1 (under partial racemization) ([12]). In as much as positive C-ions racemize very easily ([13]), it is to be supposed that the transition complex is not constructed as a cation, but rather as a complex compound, the carbon atom being positively polarized.

The evidence is too scarce at present to foretell whether a reaction would proceed according to a simple or a migration mechanism. Only certain empirical rules can be established.

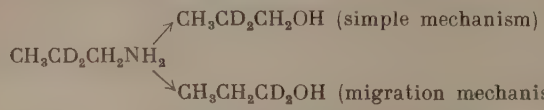
Thus, compounds containing the group CH_2X, bound with a tertiary radical, always exchange X by means of the migration mechanism. On the contrary the migration mechanism takes surely no place in such cases, as, for instance, in the reaction of isopropyl amine with nitrous acid, which gives only isopropyl alcohol ([14]). One would interpret this case as a tendency of the hydroxyl group to unite with the less hydrogenated carbon atom, as the one that is more positive. But this rule is not general. Indeed, as indicated above, the hydroxyl group unites with the more hydrogenated atom in the reaction of the conversion of cyclobutylamine into cyclopropylcarbinol.

Our judgment is the more embarrassed by the fact that many reactions of migration do not lead to any rearrangement in the usual sense of the word. For instance, the fact that a certain amount of the primary alcohol is produced in the reaction of nitrous acid with *n*-propylamine is still no proof of the reaction proceeding according to the simple mechanism. Indeed, the

migration of the methyl group would also yield *n*-propyl alcohol according to the scheme:



In similar cases the heavy hydrogen method can be applied to the determination of the alternating mechanism. Thus, 2.2-dideuterium propyl amine with nitrous acid should yield one (or both) of the two compounds, corresponding to the two alternating mechanisms:



The investigations in this direction will show, I believe, that the migration reactions are much more widespread, than it is assumed at present.

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CHEMISTRY

ON THE COMPLEX COMPOUNDS OF PALLADIUM AND COMPLEX AMINES

By A. M. RUBINSTEIN

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Our studies of complex compounds of platinum and complex amines led to the establishment of new facts about complex compounds in general. It was found that if potassium chloroplatinite is acted upon with 2am5IPy, 2am5BrPy, 2am5ClPy, the resulting compound has a trans-configuration, unlike all the reactions between amines and K_2PtCl_4 studied, which give cis-compounds. We have expressed the assumption that when a trans-form is formed, platinum is joined to the addend by means of the haloid rather than by means of nitrogen. It was, therefore, interesting to study the analogous compounds of palladium.

A study of complex palladium compounds made by other authors showed that palladium forms compounds similarly to bivalent platinum, but these compounds are less stable. In the works of A. A. Grunberg on complex palladium compounds it was shown that palladium ammoniates possess both cis- and trans-isomery. The existence of isomerization in palladium compounds makes discovery of cis-trans-isomery in them quite difficult. A. A. Grunberg produced a compound $(NH_3)_2\ Cl_2Pd$ of cis-configuration and showed that in time this cis-isomer passes into the trans-form. In pyridine complex compounds cis- and trans-isomery has not as yet been observed for palladium.

Investigation of Complex Compounds of Palladium and α- and β-aminopyridine. A study of the action of α-aminopyridine on potassium chloropalladite has shown that the introduction of aminopyridine into the inner sphere takes place very rapidly. If aminopyridine is added to a solution of K_2PdCl_4, a pinkish-red precipitate is formed at once. In this reaction two molecules of α-aminopyridine are taken per molecule of K_2PdCl_4. If the pink precipitate is quickly removed (sometimes it filters very poorly), a large-grained, bright-yellow precipitate is formed in the filtrate. A small quantity of the same precipitate forms in the wash water after washing the pink precipitate.

Investigation showed that the composition of this pinkish red precipitate is not constant. Compounds obtained from different experiments gave different palladium and chlorine contents.

Palladium content—34.24%, 33.28%, 32.68%, 33.37%, 33.66%. The ratio of chlorine to palladium was always less than 2—1.68, 1.72 etc. Theoretically palladium in [Pd4amPy] $[PdCl_4]$=29.19.

Investigation of the yellow crystalline precipitate showed that its composition is strictly constant.

Palladium content—29.46%, 29.41%, 29.21%, 29.32%, 29.3%, 29.01%. Theoretically palladium in $2amPyCl_2Pd$ =29.19.

Studies of the action of pyridine on K_2PdCl_4, made by other authors, have shown that it is impossible to produce a pure salt of the composition $[Py_4Pd]\,[PdCl_4]$, analogous to Vauquelin's salt $[(NH_3)_4Pd]\,[PdCl_4]$, by the direct action of pyridine on chloropalladite. It can be produced by the interaction of K_2PdCl_4 and $[Py_4Pd]Cl_2$. It is also impossible to produce pure $[(amPy)_4Pd]\,[PdCl_4]$ through the action of α-aminopyridine on K_2PdCl_4. This is apparently due to hydrolysis which takes place easily in palladium compounds. This is also confirmed by the fact that the ratio of chlorine to palladium in this compound equals 1.68, 1.72, i. e. is always below 2, which means that the palladium content is always high.

It is as yet impossible to establish the configuration of the yellow salt precipitated from the filtrate, since in order to do this the other isomer has to be produced, so that the properties of these salts can be compared. The precipitation of the yellow salt $2amPyCl_2Pd$ from the filtrate can be explained in two ways: if the salt is of cis-configuration, it formed as a result of very small concentrations of α-aminopyridine and K_2PdCl_4 remaining in the solution and reacting to produce $2amPyCl_2Pd$; if it is of trans-configuration, it was produced from $4amPyPdCl_2$ due to the unstability of this compound. When α-aminopyridine reacts with K_2PdCl_4, small quantities of $4amPyPdCl_2$ may form along with the other compounds.

Determination of the Conductivity of the Yellow Salt $2am\,PyCl_2Pd$. This salt is completely insoluble in water, even when diluted to $^1/_{10000}$. The following table shows how the conductivity varies in time.

T min.	10	15	20	25	30	35	40	60
$H\times10^7$	37.8	54.4	66.9	73.3	81.1	85.5	97.4	100.8

T min.	65	80	85	105	120	135	145	23 hrs
$H\times10^7$	122	135.7	142.7	162.1	175.1	185	194	313.1

The substance apparently dissolves gradually in water due to hydration.

We thought it would be interesting to investigate the action of an excess of aminopyridine on the pinkish-red salt produced through the action of amPy on K_2PdCl_4. Under the action of aminopyridine in the cold, this salt gradually dissolves. The solution turns red, and a cream-coloured precipitate begins to appear. The precipitate dissolves fairly well in water. Analysis shows that this precipitate has the following composition: $4amPyPdCl_2$.

A study of the thermal decomposition of this compound shows that it begins to decompose at as low a temperature as 110—120°, and the reaction is completed at 175°. Initial weight of sample—0.0570. When dried at 110° 15 hrs—0.0549; at 123° 24 hrs—0.0530; at 145° 4 hrs—0.0370; at 175°—0.0363. Temperatures above 175° do not cause further decomposition.

Weight of palladium in this sample—0.0109. Per cent palladium—19.13. Per cent palladium in dry sample—30.02. Theoretical palladium content in $4amPyPdCl_2$—19.41, in $2amPyCl_2Pd$—29.19.

Apparently, upon heating this salt decomposes similarly to palladium tetramines which contain ammonia or pyridine in the inner sphere, i. e. two molecules of aminopyridine are detached.

If a solution of $4amPyPdCl_2$ is acted upon with potassium chloroplatinite, a yellow precipitate is formed, consisting of a mixed platinum-palladium salt of the following composition: $[4amPyPd]\,[PtCl_4]$. If this solution is acted upon with potassium chloropalladite, the result is a red precipitate of varying

composition. This is due to the fact that the bond between palladium and the aminopyridine molecule is weak, and consequently depolymerization may take place under the action of K_2PdCl_4. This case of depolymerization was first observed by A.A.Grunberg in his works on complex palladium compounds.

Investigation of Complex Compounds of Palladium and Aminopyridine Halogen-Derivatives. a) Action of 2am5IPy on K_2PdCl_4. Investigation of the action of 2am 5IPy on K_2PtCl_4 has shown that a compound of the following composition is formed: $(2am5IPy)_2Cl_2Pt$. We have shown in previous publications that this compound is of trans-configuration. It has been assumed that in this case the platinum is attached to the addend through iodine, rather than nitrogen.

The reaction between 2am 5IPy and K_2PdCl_4 was brought about in an aqua-alcohol medium. 2 am5IPy and K_2PdCl_4 begin to react appreciably immediately, giving a yellow crystalline precipitate. Repeated analyses of this compound show that it is of a strictly constant composition expressed by the following formula: $(2am5IPy)_2Cl_2Pd$. It was necessary to prove that the formula of this salt is $(2am5IPy)_2Cl_2Pd$ and that it is not the polymer $[(2am5IPy)_4Pd]\ [PdCl_4]$. This is confirmed by the action of pyridine on the compound produced from the reaction between 2am5IPy and K_2PdCl_4. Under the action of pyridine this salt dissolves rapidly, and after a few minutes (sometimes seconds) the solution recrystallizes giving a yellow precipitate. The salt dissolves poorly in water and alcohol. This compound was produced many times, and the action of pyridine was always the same. Analysis of the yellow precipitate shows that it has the following composition: Py_2Cl_2Pd. The formation of such a compound is possible only if the compound produced in the reaction between 2am5IPy and K_2PdCl_4 has the formula $(2am5IPy)_2Cl_2Pd$ and not $[(2am5IPy)_4Pd]\ [PdCl_4]$.

After Py_2Cl_2Pd has been filtered off, free 2am 5IPy can be observed in the filtrate, and isolated in the form of shiny scales. Ammonia has no appreciable effect upon $(2am5IPy)_2Cl_2Pd$ in the cold. After standing some time, or after being heated over a water bath, the precipitate dissolves. The solution turns yellow and free 2am5IPy, being insoluble in water, precipitates. This precipitate can be filtered off, washed with water, weighed, and serves to prove that the 2am5IPy has been substituted with ammonia. The quantity of 2am5IPy produced gives grounds for estimation of the quantitative side of this reaction. If the ammonia solution is treated with hydrochloric acid after 2am5IPy has been filtered off, a yellow crystalline precipitate of palladozoamine is formed. The action of ammonia and hydrochloric acid can be expressed as follows:

$$(2am5IPy)_2\,Cl_2Pd + 4NH_3 \rightarrow (NH_3)_4\,PdCl_2 + 2\,(2\ am5IPy).$$

$$(NH_3)_4\,PdCl_2 + 2HCl \rightarrow (NH_3)_2\,Cl_2Pd + 2NH_4Cl.$$

b) Reaction between 2am5BrPy and K_2PdCl_4. The reaction is brought about in an alcohol-aqua medium, since 2am5BrPy is quite soluble in alcohol, but insoluble in water. Under the action of 2am5BrPy, K_2PdCl_4 immediately gives a yellow crystalline precipitate. The precipitate is homogeneous and of constant composition. Repeated analyses of this compound show that its formula is: $(2am5BrPy)_2Cl_2Pd$.

In order to prove this formula, we investigated the action of pyridine on $(2am5BrPy)_2Cl_2Pd$. When heated, $(2am5BrPy)_2Cl_2Pd$ dissolves gradually in pyridine, and a bright yellow precipitate begins to fall out of the solution. This precipitate dissolves poorly in water. Analysis shows that this precipitate has the following composition: Py_2Cl_2Pd. If $(2am5BrPy)_2Cl_2Pd$ is dissolved in a large quantity of pyridine, or if this reaction is carried on for a long time under the action of heat, a light cream precipitate of the composition

$[Py_4Pd]Cl_2$ is formed upon cooling. This precipitate is quite unstable, losing two molecules of pyridine to form Py_2Cl_2Pd even while being washed. The action of pyridine upon $(2am5BrPy)_2Cl_2Pd$ shows that the formula accepted for this salt is correct.

Under the action of ammonia $(2am5BrPy)_2Cl_2Pd$ dissolves gradually when heated over a water bath. The solution is colourless, but upon cooling there appears a crystalline precipitate of the initial 2am5BrPy. After the 2am5BrPy has been filtered off, hydrochloric acid is added to the solution. This gives a precipitate of palladozoamine, $(NH_3)_2Cl_2Pd$. As may be gathered from the above, the action of pyridine and ammonia on $(2am5BrPy)_2Cl_2Pd$ is analogous to their action on $(2am5IPy)_2Cl_2Pd$.

c) Action of 2am5ClPy on K_2PdCl_4. The reaction is performed in the same manner as with iodoaminopyridine and bromoaminopyridine. During the reaction a yellow crystalline precipitate is formed. Analysis showed that the compound has the following strictly constant composition: $(2am5ClPy)_2Cl_2Pd$. Investigation of the action of pyridine upon this salt has shown that it dissolves well in pyridine in the cold, and after some time there appears a yellow crystalline precipitate. The composition of this precipitate is: Py_2Cl_2Pd.

Ammonia does not react with $(2am\ 5ClPy)_2Cl_2Pd$ in the cold. Upon heating the salt dissolves, and after cooling white crystals of the initial 2am5ClPy appear. After filtering off the 2am5ClPy, hydrochloric acid is added to the solution. This leads to the formation of a yellow crystalline precipitate of palladozoamine: $(NH_3)_2Cl_2Pd$.

Thus, it has been shown that under the action of aminopyridine halogen derivatives (2am5IPy, 2am5ClPy, 2am5BrPy), compounds of the following composition are formed: $(2am5X)_2Cl_2Pd$. Polymers do not form during this reaction. This shows that during the formation of complex compounds of palladium and pyridine halogen derivatives, there form, just as in the case of platinum, compounds which do not fit in with the laws known up till now.

At present a study is being made of complex compounds of palladium and pyridine halogen derivatives. This study will offer a final answer to the problem of the laws governing the formation of complex compounds with aminopyridine halogen derivatives.

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GEOCHEMISTRY

RARE EARTHS IN PLANTS AND SOILS

By I. D. BORNEMAN-STARINKEVITCH, S. A. BOROVICK and I. B. BOROVSKY

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The practical problem of the presence of rare earths in living matter is interesting with regard to the assimilability of rare earths and their effect on the development of organisms. This problem was first raised in 1878 by A. Cossa (1), who proved that rice and tobacco contain rare earths. In 1924 one of us (2) determined their content in the tooth of the modern horse (0.024%) and in fossil *Helicoprion* (0.66%). In 1930 M. P. Byelaya and T. F. Borovick-Romanova discovered rare earths spectroscopically in the coal of the Kuznetsk basin (La, Ce, Yb, Gd, Ho) in the ashes of *Litothanium* (La, Y), in the ashes of *Lemna minor* (Tb, Yb) and in maple leaves (La, Ce, Y). In 1938 Robinson and Scribner (3) studied the leaves of hickory, *Symplocas*, birch, black currant, soya, wheat, grape vine, ambrosia. In hickory, which was the highest in rare earths (0.2% by dry weight), they found Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Er, Yb and made an approximate estimation of their relative content. In the same year H. Lux (4) studied the ashes of an ox's bones, and estimated the quantity of T. R. in them as 8×10^{-6}%. An X-ray-spectral analysis gave their relative distribution. Sc, Y, La, Ce, Nd, Gd, Dy were found; of these Y, La, Ce and Nd prevailed.

The problem of the occurrence of rare earths in living matter has not yet been definitely settled. We decided on several objects to work out a quantitative method of finding the sum of rare earths, to investigate their approximate composition spectroscopically and to try to find whether they accumulate anywhere.

1. The Method of Chemical Analysis. As far back as 1934 in analyzing loparite rocks with a rare earth content of an order of 0.2—0.5%, and in 1938 in the work of H. Lux (4) in the analysis of bones the rare earths were observed to possess a curious property of not precipitating quantitatively as hydroxides in the presence of large quantities of iron and aluminium. This was confirmed in the first experiments on analyzing soils. Therefore, the separation of rare earths was based on their isomorphism with calcium (5), which precipitated first in the course of the analysis and carried the rare earths along with it. A little gelatine was added to the hydrochloric extract of a 50 g sample to coagulate the dissolved silicic acid. After calcining gently the insoluble residue was evaporated several times to dryness with hydrofluoric and hydrochloric acids; hydrochloric acid was added and the solution was filtered with a new portion of gelatine. The residue was treated with hydrofluoric and sulphuric

acids, heated to remove excessive sulphuric acid, and dissolved in hydrochloric acid; rare earths were not discovered spectroscopically in the small insoluble residue.

Isolation and Determination of Total Rare Earths. The solution thus obtained was evaporated to 600—700 ml, and a solution of 1—2 g calcium chloride followed by oxalic acid (200 ml of a 10% solution) was added; the solution was reduced with ammonia to neutral reaction and oxalic acid was again added until a voluminous precipitate disappeared and a fine crystalline precipitate of calcium oxalate containing the rare earths made its appearance. The precipitate was filtered on the next day, calcined and dissolved in hydrochloric acid; the cycle of dissolving and precipitating was repeated 2—3 times. The last, greatly diminished precipitate was dissolved in hydrochloric acid, precipitated with ammonia and filtered cold. The residue on the filter was dissolved in a few drops of hydrochloric acid, the filter was washed several times with water and the solution in a small volume was precipitated with oxalic acid from the acid solution. The next dissolving of the calcined precipitate, followed by precipitation again with ammonia and oxalic acid, gave a pure rare earth sum, whose composition was deciphered spectroscopically (S. A. Borovick).

The analysis of plant ashes differed from that of soils only in the fact that they were easier to dissolve and that it was unnecessary to add calcium. If the rare earth content was very small (*Linaria*), complete purification from foreign elements was not attained, and the quantitative estimation was made from the data of spectral analysis. The spectroscopic determinations of rare earths in their isolated sum were made on arc spectra in the wavelenght interval 2500—3500 Å; this made it possible to identify the separate elements of the rare earth group clearly; only Sm, Nd and Pr have no bright lines in this interval. Neodymium and praseodymium were determined from their absorption spectra. Samarium was not determined at all in most cases.

Table 1

X-ray Spectrum Verification of the Completeness of Isolation of T.R.

Material	Weighed portion, g	Eu_2O_3 added	Eu_2O_3 + + T. R. isolated	T. R. %	% Eu_2O_3 calculated	% Eu_2O_3 from X-ray analysis
T.R. from Chibiny apatite	0.0547	0.0061	0.0605	99.5	10.9±0.2	13.0±2
Chibiny soil; terraces around mount Vudyavrchorr	75.01	0.0038	0.0209	0.03	18.2±1	20.5±2
Ash of the *Senecio paludosus* plant	67.01	0.0008	0.0018	$1.5 10^{-3}$	44.4±6	37.8±2

Verification of the Quantitative Estimation of the Rare Earths. In order to judge the completeness of isolation of the rare earths by this method, analyses were made of samples with preliminary additions of known quantities of spectroscopically pure europium oxide. After isolating the sum of rare earths, the per cent of europium oxide was determined by X-ray spectral analysis (I. B. Borovsky) and compared with the quantity of Eu_2O_3 added to the test object before the experiment. The transitional coefficient between the relative line intensities Eu La_1 = =2116. 3XE and Nd L β_1 =2162.2 XE and the content of these elements

		Gravimetric chemical analysis				Spectral analysis													
		No.	% ash	% T. R. in ash	% T. R. to live weight	Y 39	La 57	Ce 58	Pr 59	Nd 60	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tu 69	Yb 70	Lu 71
Plants	Whole plants	1	1.2	$0.2\cdot10^{-3}$	$0.2\cdot10^{-5}$	II	II	II	—	—	—	—	III	—	—	—	—	—	III	—
		2	3.5	$0.4\cdot10^{-3}$	$1.4\cdot10^{-5}$	I	I	I	III	II	—	II	II	—	—	—	III	—	III	—
		3																		
		4	4.8	$0.8\cdot10^{-3}$	$3.8\cdot10^{-5}$	I	I	I	III	I	—	II	II	—	γ	γ	γ	—	III	—
		5	1.1	$2.9\cdot10^{-3}$	$3.2\cdot10^{-5}$	II	I	I	III	III	—	—	γ	—	—	—	—	—	—	—
	Parts of plants	6	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		7	2.2	$1.6\cdot10^{-3}$	$3.5\cdot10^{-5}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		8	—	$1.7\cdot10^{-3}$	—	I	I	I	III	II	—	III	II	—	γ	γ	γ	—	III	—
		9	—	$4.3\cdot10^{-3}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		10	3.1	$5.1\cdot10^{-3}$	$15.6\cdot10^{-5}$	I	I	I	III	II	—	γ	II	—	—	γ	—	—	III	—
		11	—	$5.1\cdot10^{-3}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Soils		12	85.8	$2.0\cdot10^{-2}$	$1.4\cdot10^{-2}$	I	I	I	III	II	—	III	II	III	γ	—	III	—	II	III
		13	—	$2.0\cdot10^{-2}$	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		14	93.9	$2.1\cdot10^{-2}$	$2.0\cdot10^{-2}$	—	—	43±5% *	—	—	—	—	—	—	—	—	—	—	—	—
		15	—	$1.0\cdot10^{-2}$	—	I	I	I	III	II	—	γ	III	—	γ	—	III	—	III	III
		16	41.3	$4.8\cdot10^{-2}$	$2.0\cdot10^{-2}$	I	I	50% *	III	II	—	II	II	III	γ	—	III	—	III	III
		17	72.2	$2.0\cdot10^{-2}$	$1.4\cdot10^{-2}$	—	—	I	—	—	—	—	—	—	—	—	—	—	—	—
Sequan clay		18	79.4	$1.4\cdot10^{-2}$	$1.1\cdot10^{-2}$	(3.4)	19.7	42.7	8.3	20.7	1.7	—	(2.2)	—	(1.1)	—	(0.2)	—	—	—
						Roentgenospectral analysis														

* Limit after the chemical, iodate method.

1. *Linaria genistefolia* (Scroph.) —Staroselye, Reserve of A. C. Uc. SSR.
2. *Chenopodium album* (Chen.) —Urovsky expedition, R. Zola.
3. » » » —Zvenigorod.
4. *Atriplex nitens* (Chen.) —Staroselye, Reserve of A. C. Uc. SSR.
5. *Lupinus* —Red Beacon, Experim. station near Moscow.
6. Larch needles —Urovsky expedition, at Yamkun.
7. Birch leaves — » » grove at Yamkun.
8. Asp wood —Moscow. Bought at the lumberyards.
9. Twigs and leaves of *Buxus sempervirens* —Batumi, Botanic gardens.
10. Beet leaves, *Beta* (Chen.) —Kiev.
11. Maple leaves —Kiev.
12. Podzol soil over clay —Leningrad.
13. Black soil of Azov Sea Region —Salsk station, North Caucasus.
14. Argillaceous forest soil —Sovhoz woods at the «Krasnaja Poljana»
15. Podzol argillaceous soil —Forest Resort of the Timiryazev Academy of Agriculture, Moscow
16. Soil from mountainous tundra —Chibiny, East slope of Vudyavrchorr mount.
17. Red earth —Bamboo forest—Batumi.
18. Sequan clay —Lopatinski mine

by weight, was determined preliminarily in order to make a quantitative X-ray spectral analysis of europium.

The transitional coefficient was obtained on artificial mixtures of Eu_2O_3 and Nd_2O_3. In one of the mixtures the filter was BaO, in the other—La_2O_3. The sample was weighed on a microbalance with accuracy to 0.005 mg, after which the mixture was dissolved in nitric acid, the solution evaporated to dryness and the residue calcined in order to mix the constituents as well as possible. The ratio Eu: Nd in the first mixture was 0.512, and in the second mixture—0.603. The spectrograms were taken with a spectrograph after Johann's method: quartz crystals $d10\bar{1}0 = 4.246$ Å; the spectra were produced in the 2nd order of reflection at 23 kV and 15 mA. In all, 10 spectrograms were taken, using a fresh portion of mixture in each case. The average value of the transitional coefficient from 10 photomicrographs was:

$$\frac{Eu}{Nd} = 0.75 \frac{IEuL\alpha_1}{INdL\beta_1}$$

The Nd content in relation to the cerium group was determined in each of the analyzed tests (T. R. from the *Senecio* plant, T. R. from Chibiny soil and T. R. from Chibiny apatite) and was found equal to $Nd_2O_3 = 16.0\%$. It was on the basis of this Nd content that the quantity of Eu_2O_3 in the isolated sum of rare earths was determined. The above transitional coefficient and the determined Nd_2O_3 content give the following figures for Eu_2O_3 content, set forth in the last column of Table 1.

A comparison of the Eu_2O_3 calculated and the Eu_2O_3 from X-ray analysis shows that this method is quite reliable for small quantities of rare earths.

II. Analysis Results. The results of the analysis are given in Table 2. Spectroscopic data have the following symbols: I—strong lines, II—middle lines, III—faint lines, γ—very faint lines,— —no lines. The rare earths isolated from Sequan clay were analyzed with the roentgenoscope (I. B. Borovsky), the figures represent the per cent referred to the sum of rare earths; the figures in brackets are approximate and are qualitative in nature. Among whole plants there is some accumulation of rare earths in *Lupinus*; among parts of plants—in beet leaves and maple leaves. Analysis of soils from various localities give quite similar results, close to 0.02%. Chibiny soil contains twice the concentration of rare earths in per cent of ash and the same order of concentration in per cent of air-dry soil. The data from soil analyses confirm Clarke's ([7]) opinion that rare earths are widespread in rocks.

The cerium group prevails in all cases. In order to make a more complete spectroscopic estimation of the elements of yttrium group present, cerium was removed after the iodate method (50%) in two soils—Leningrad and Chibiny and then the rest of the rare earths were estimated spectroscopically from their sum (Table 3).

Table 3

Rare Earths after Removing Ce

	Y 39	La 57	Ce 58	Pr 59	Nd 60	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tu 69	Yb 70	Lu 71
Chibiny and Leningrad soils	I	I	γ	II	I		II	I	III	III	γ	II		I	II

It is curious to note the presence of middle lines of rarely occurring elements with uneven atomic numbers (71 and 63) and the full identity of the data for both soils.

The T. R. concentrations in the ashes of whole plants varied from $2 \cdot 10^{-4}$ to $3 \cdot 10^{-3}$; in the ashes of the green parts of plants—from 0 to $5 \cdot 10^{-3}$.

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MINERALOGY

ANALYSIS AND CHEMICAL FORMULA OF AESCHYNITE

By I. D. BORNEMAN-STARINKEVITCH

(Communicated by V. I. Khlopin, Member of the Academy, 8.VII.1940)

The name «Aeschynite» (from the Greek word αἰσχυνή (aeschyne), meaning shame) was given by Bercelius because chemists were unable to reduce this mineral to its components. On the basis of analyses by Marignac (1867) and Rammelsberg (1877) Doelter, in his handbook, assumes that aeschynite is composed of two chemical compounds:

$$x\,(Ca, Fe)_2Nb_4O_{12} = 2(Ca, Fe)Nb_2O_6 + y\,Ce(Ti, Th)_4O_{11}$$

In 1925 the author repeated the analysis of aeschynite in order to eliminate assertions made by Hauser and Herzfeld in 1910 and Goldschmidt in 1924([4]), doubting the existence of aeschynite in the Urals; Goldschmidt assumed that an error had been made in the chemical analysis in determining the yttrium group and that aeschynite had been confused with a blomstrondine rich in the yttrium group.

In 1930 the author proposed for aeschynite the following chemical formula:

$$xCa_3(Ti,Th)_3Nb_2O_{14} + yCe_2(Ti,Th)_3Nb_2O_{14}$$

assuming, as had been accepted at one time by F. Zambonini, substitution of Ca by rare earths in proportion to their equivalents $3CaO \rightarrow Ce_2O_3$ and the isomorphic substitution $Th \rightarrow Ti$.

The chemical formula of aeschynite can be deduced much more simply if the mineral is considered a solid solution of chemical compounds belonging to a single type. It is required to find the simplest formula ([7–10]) into which would fit all the cations and anions of various valencies found by chemical analysis.

Material for analysis was furnished by B. A. Makarochkin from mine 127 of the Ilmen Reserve, Urals, and was carefully selected under a binocular magnifying glass.

I. Run of Analysis

Aeschynite is easily and completely decomposed with concentrated sulphuric acid. The undecomposed mineral particles were kept from being coated with insoluble thorium and cerium sulphates after the following method: a test portion of 0.4—0.5 g was wetted with water and boiled in a quartz conic flask with 4—10 ml H_2SO_4 (1 : 1) until strong fumes of SO_3 arose and the contents of the flask became a white doughy mass; toward the end it was necessary to heat with care in order to avoid spraying. Then the flask was cooled and the solution was diluted in cold water to 10—15 ml. Everything dissolved except a small insoluble residue ($PbSO_4 + SiO_2$) and the undecomposed mineral. The residue was boiled, evaporated and diluted in water again

2—3 times until the mineral was entirely decomposed. In some cases, while dissolving for the last time in water, metatitanic and niobic acids precipitated out as a result of hydrolysis. When this happened, a few ml of H_2O_2 were added, the solution was heated, after which the insoluble residue was filtered off and the SiO_2 and PbO in it were determined. The filtrate was diluted to a volume great enough for the concentration of H_2SO_4 to be less than 0.3 *N*; the rare earths and Th were precipitated with oxalic acid. On the next day this precipitate was filtered; calcium was precipitated in the filtrate by neutralizing with ammonia and acidifying with oxalic acid to separate it from Ti, Nb, Ta, Fe. The filtrate from the calcium was acidified with sulphuric acid up to 10% by volume and Ti, Nb, Ta, Fe were precipitated with an excess of cupferron. Rare earths were detected in the filtrate from the cupferron precipitate in some cases when the concentration of the sulphuric acid was not maintained carefully enough while precipitating them. The first rare earth precipitate and thorium should always be checked for calcium, and the calcium precipitate—for rare earths. Thorium was separated after the iodate method. In the filtrate from thorium, cerium was oxidized with bromate and also isolated in the form of iodate; in the filtrate from cerium the iodates were reduced with oxalic acid, the oxalates of the rare earths were filtered, calcined, dissolved, and reprecipitated with oxalic acid, in order to separate them from a large excess of potassium salts which had been introduced while precipitating the iodates. The yttrium and cerium groups were separated by means of mixed potassium sulphate salts.

The cupferron precipitate was melted with $KHSO_4$, the melt dissolved in tartaric acid, and iron precipitated with ammonium sulphate. Most of the niobium in the filtrate was separated through tartaric acid hydrolysis with hydrochloric acid. After calcining and fusing with $KHSO_4$ the titanium in the niobium was determined colorimetrically. Titanium was precipitated out of the filtrate from niobium with cupferron; the precipitate was calcined, and the rest of the niobium was extracted from it after the pyrosulphate-tannin method and, having been dissolved in HF, was reprecipitated with boric acid according to V. C. Bykova's method ([11]).

The degree of oxidation of cerium was not determined.

The degree of oxidation of titanium was determined in the following manner. Iron sulphate solution was added to the sample, which was then decomposed with sulphuric acid in a current of CO_2. On passing into solution trivalent titanium would have reduced ferric oxide to ferrous oxide:

$$Ti_2(SO_4)_3 + Fe_2(SO_4)_3 = 2Ti(SO_4)_2 + 2FeSO_4$$

This did not happen, and permanganate titration showed ferrous iron in the quantity corresponding to its content in the mineral. Therefore titanium in aeschynite is quadrivalent.

II. Results of the Analysis

1. Spectroscopic analysis by Prof. S. A. Borovick

Zr, Be, As, Na, K	none
Sr, Al, Mg	traces of lines
Pb (0.2), Sn (0.05), Ca, Mn (0.1), Si	faint lines
Fe	middle lines
Nb, Ti, Th, T.R.	strong lines
Ta	?

2. X-ray analysis by I. B. Borovsky
   a) Uranium was not detected
   b) Ratio of rare earths of the cerium group
      Ce : La : Nd : Pr = 1 : 0.71 : 0.43 : 0.24
   c) Ta_2O_5 = 0.53%.

3. Chemical analysis by the author

sp. gr.	Nb_2O_5	Ta_2O_5	TiO_2	SiO_2	SnO_2	ThO_2	CeO_2	$(La, Nd, Pr)_2O_3$
5.339	25.35	0.94	23.79	0.50	(0.05)*	17.42	10.84	13.43

ΣY_2O_3	Fe_2O_3	FeO	MnO	CaO	PbO	H_2O^{-110}	H_2O^{+110}
0.89	1.56	1.14	(0.10)*	2.65	0.12**	0.14	0.94

Total 99.86%

III. Deduction of formula

Resolving the percentage composition to atomic ratios we get:

Nb	Ta	Ti	Th	Ce	ΣLa,Nd,Pr	ΣY	F̈e	F̈e	Mn	Ca	Pb	(H)
1906	43	2974	660	630	819	67	195	158	14	472	5	1044

We have ions of two different radii: A=Ce, Th, T. R., Ca=1.1 Å, and B=Nb, Ta, Ti, Fe, Mn=0.65 Å. The number of ions A is $660+630+819+67+472=2648$, while the number of ions B is $1906+43+2974+195+158+14=5290$, i. e. the number of ions of 0.65 Å radius is twice the number of ions of 1.1 Å radius. We assume the simplest type of formula $A(BX_3)_2$ where the radius of ions A is 1.1 Å; of ions B, 0.65 Å; and of ions X, 1.32 Å.

If this assumption is correct, then 1) the ratio of the sum of valencies of the cations A^+ to the sum of valencies of the anions BX_3^-, according to analysis data, should be unity, and 2) all the analysis data should fit exactly into a formula of the type AB_2X_6, i. e. there should be the following compounds: (Th, Ce^{IV}) Ti_2O_6, Ce^{III},$NbTiO_6$, $Ca_2Nb_2O_6$, $CaFe^{\cdots}NbO_4(OH)_2$***, $CaFe^{\cdot\cdot}NbO_3(OH)_3$*** and there cannot be any of the following compounds:

$$CaTiO_3,\ Ce_2(TiO_3)_3,\ Th(Nb_2O_6)_2;$$

whereby the ratio $(BX_3)^-:A^+=2$ could be satisfied, if certain coefficients were selected, but entirely different ratios Nb:Ti:Fe and respectively Ca:T.R.:Th would be required.

Calculating the valencies for A^+ and $(BX_3)_-$ from the analysis data we get:

for Ce^{IV}

Valency of cations $A^+=660\times4$ (Th) $+630\times4$ (Ce) $+(819+67)\times$ $\times3$ (T. R.) $+472\times2$ (Ca) $=8762$

for Ce^{III}

Valency of cations $A^+=8132$.

Valency of anions $BX_3=1906\,(NbO_3)^{-1}+2974\times2\,(TiO_3)^{-2}+$ $+195Fe^{\cdots}O(OH)_2^{-1}+135Fe^{\cdot\cdot}(OH)_3^{-1}=8184$.

The ratios:

1) $A^+:BX_3^-=\frac{8762}{8184}=1.07$.

2) $A^+:BX_3^-=\frac{8132}{8184}=0.99$

The second is closer to unity than the first, and there are probably more Ce^{III} ions than Ce^{IV} ions.

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* Estimation from spectroscopic and X-ray analyses for lack of test materials.

** The figure for PbO is probably somewhat low; according to estimation from the spectroscopic and X-ray analyses it should be closer to 0.2%.

*** The so-called «hydrate» or constitutional water should be introduced into the formula in the form of a hydroxyl, which is capable by its dimensions of substituting oxygen. In this manner the formula for the aqueous compounds becomes of the same type as that of the other inaqueous compounds, which constitute the solid solution of this mineral.

The composition of this aeschynite can be expressed in terms of the following chemical compounds, which can substitute one another in the crystal lattice or which are capable, in other words, of forming a solid solution.

From the number of Fe^{***} ions	195 Ca	$Fe^{***}NbO_4(OH)_2$	}	7.4%
» » » » Fe^{**} ions	158 Ca	$Fe^{**}NbO_3(OH)_3$	}	6.0%
From the Ca ions left	119 Ca	Nb_2O_6		4.5%
» » Nb » »	1358 Ce	$TiNbO_6$		51.6%
From the number of Th ions	660 Th	Ti_2O_6		25.1%
From the Ti ions left	140	$Ce^{IV}\ Ti_2O_6$		5.3%
	2630			99.9%

According to the method of writing this composition the error of all determinations is reduced formally to errors in determining T. R. and water.

According to the analysis there are

$$630+819+67=1516 \text{ T. R. ions.}$$

According to the above formula there are

$$1358+140=1498 \text{ T. R. ions;}$$

difference = 18, which corresponds to an excess of 0.30% of rare earths.

According to the analysis there are 1044 H ions.

According to the above formulae there are

$$(195\times 2)+(158\times 3)+864 \text{ H ions;}$$

difference = 180, which corresponds to an excess of 0.16% of water.

The analysis data give us the whole of the established formula.

If the same calculations are made for previous analyses, the results are somewhat less satisfactory, but quite confirm the general formula AB_2X_6. The discrepancy between the analysis data and the formula are entirely due to our inability up to recently in separating niobium, tantalum, titanium and the rare earth group.

Independently of the spatial arrangement of the ions, we have obtained an accurate deduction of the chemical composition of aeschynite, which is a solid solution of thorium meta-titano-niobates, the rare earths and calcium, with a general formula

$$AB_2X_6 = x\,|(Ce^{IV}, Th)\,||Ti_2|O_6 + y\,|T.R.\,||NbTi|O_6 + z\,|Ca\,||Nb_2|O_6 + u\,|Ca\,||Fe^{***}Nb|O_4(OH)_2$$

Crystalchemists would express it in a general way as:

$$|Ca, Ce^{***}, Th\,||\,Nb, Ta, Ti, Fe^{***}Fe^{**}|_2\,|O,(OH)|_6$$

which is incorrect so far as there is a solid solution of definite chemical compounds, and which does not give any idea of the quantitative relations between anions and cations of various valencies.

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GENETICS

ON THE MANIFOLD EFFECT OF THE *CINNABAR* GENE IN *D. MELANOGASTER*

By M. E. NEUHAUS

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By a manifold or pleiotropic effect of a gene is understand that a given gene produces its effect in different parts of the organism. It is unknown whether a given gene causes the formation of different genoproducts in different parts of the organism, which is responsible for the different effect, or whether the genoproduct formed is identical, while its effect varies under different conditions. Since modern genetical literature contains no experimental data on this problem, the material described below may be of some interest.

Flies with the mutation *cinnabar* eye colour are deprived of yellow pigment granulas in the pigment cells of the eyes (1), their ocelli being colourless (2) (normal flies have brown ocelli), and the Malpighian tubules are lighter than in the normal (3) (in the normal flies they are yellowish). Besides these we have obtained two mutant allels of the *cinnabar* gene having a lethal effect in homozygous condition.

The method of obtaining lethal allels consisted in the following: normal males were X-rayed (5000 r) and crossed with *b cn* females. The F_1 individuals manifesting *cn* were crossed individually with $\frac{Cy}{L}$ flies. Two categories of flies (*L* and *Cy cn*) were obtained from this cross (the *Cy* chromosome contains any mutant allel of the *cinnabar* gene). The *Cy cn* males were individually crossed with $\frac{Cy}{L}$ females. The *Cy cn* offspring from these males were crossed with each other. The absence of non-*Cy* flies indicates that along with the *cn* mutation some lethal mutation had arisen in chromosome II under the effect of X-rays. Irradiation caused the emergence of the *cn* mutation in 11 chromosomes, and 5 of these chromosomes gave the lethal effect in homozygous condition. The following cross was carried out in order to find out whether the lethal effect is connected with the *cn* locus. The $\frac{Cy}{cnl}$ males (*cn l*, the irradiated chromosome, where the lethal and *cn* had arisen) were crossed with normal females. The non-*Cy* F_1 females were crossed with $\frac{Cy}{cnl}$ males. If the newly arisen lethal is not connected with the *cn* gene and if the *cn l* chromosome has no inversions, this type of crossing ought to give *cn* progeny. In none of the 5 newly obtained *cn l* chromosomes did we succeed to separate the lethal from *cn* through crossing-over. Besides, corresponding crosses showed that these 5 lethals are homologous. Investigations of the salivary gland chromosomes showed

that only in two cases of the 5 *cn l* chromosomes studied (namely, *cn* l_3 and *cn* l_9) chromosome rearrangements were absent. Unfortunately, the locus of the *cn* gene in the salivary gland chromosomes is so far unknown; yet, an accurate analysis of the assumed localization region showed the absense of any kind of small rearrangements in the *cn* l_3 and *cn* l_9 chromosomes. Thus, there is some reason to suppose that minute deficiencies for the *cn* gene or lethal allels of the *cn* gene have arisen in the *cn* l_3 and *cn* l_9 chromosomes.

An extract of normal larvae and pupae was added to the food in the vials containing 1—2-day-old larvae of *cinnabar* (4). Within 9—12 hours the effect of the extract becomes manifest. The colour of the cells of the Malpighian tubules changes, and with the advancing age a gradual intense formation of yellowish-green pigment grains is clearly observed in the cells of these tubules. As the extract is yellow and the Malpighian tubules are excretory organs, one can suppose that the intense formation of pigment is merely the deposition of by-products rather than the result of the action of genohormones. However, this assumption is disproved by the following experiments. One-two day old *w*, *cn bw*, and *bw st* larvae with colourless Malpighian cells were fed large doses of extract of normal larvae, pupae and imago. No deposition of yellow grains took place in the cells of *w* and *bw st* individuals, while in the *cn bw* larvae a large number of yellowish-green granulas appeared in the cells of the Malpighian tubules.

The imago of the *cinnabar* larvae, receiving an extract of normal larvae and pupae, showed a change of eye colour towards the normal, while after administration of large dosages of extract (4—5 g extract of normal larvae and pupae per vial containing 75—100 1—2-day-old larvae) an eye colour was obtained which did not differ from the normal. As to the colour of the ocelli, it changes more slightly towards the normal. We frequently observed *cn* flies whose larvae had been receiving an extract of normal larvae and pupae and whose eye colour did not differ from that of the normal, the colour of the Malpighian tubules being even more intense than in the normal, while the ocelli which were considerably lighter than the normal pointed to the fact that these flies were of the *cn* genotype.

Our observations, thus, lead to the conclusion that the Malpighian tubules are the most sensitive to the $\overset{+}{cn}$ genohormone, next come the eye cells, while the ocelli are the least sensitive.

Prior to start the experiments with the influence of the $\overset{+}{cn}$ genohormone on the viability of the lethal zygotes, it was of interest to make clear when and why these lethal zygotes had perished. Preliminary material showed that the larvae perish at the stage between the second and third age. As to the cause, it still remains unknown. Nevertheless, we decided to begin experiments with feeding. Into vials containing developing larvae from $\frac{Cy}{cnl_3}$ and $\frac{Cy}{cnl_9}$ flies a comparatively large amount of extract of normal larvae and pupae was added. In the control vials containing *cn* l_3 larvae 436 *Cy cn* flies, and 1 ♀ and 1 ♂ non-*Cy* were obtained. From the vials where the larvae received the extract, we obtained 558 *Cy* flies with non-*cn* eye colour, but with *cn* ocelli colour, 4 ♀♀ and 3 ♂♂ non-*cn* and non-*Cy* with very crumpled wings. The control *cn* l_9 vials gave 276 *Cy cn* flies and 1 non-*Cy cinnabar* female. The following hatched from the test vials: 284 *Cy* non-*cn* flies, however, according to their ocelli, they had the *cn* genotype; 1 male and 2 females non-*Cy* non-*cn*, but of the genotype *cn* according to the ocelli. The emergence of non-*Cy* flies in the control and test vials ought not to be taken to mean that individuals homozygous for the lethals had survived. In the balanced $\frac{Cy}{L}$ stock *Cy*

non-*L* and *L* non-*Cy* individuals are of rather frequent occurrence. Such individuals apparently arise as the result of double crossing-over. However, more than 1% of such individuals was found in the *cn* l_3 vials. This high frequency can hardly be accounted for by crossing-over.

If the *cn* l_3 flies found in the test vials practically survived owing to the fact that their larvae had received an addition of cn^+ genohormone extract to their food, their intercrossing should result in the absence of imago and pupae, while their intercrossing with $\frac{Cy}{cnl_3}$ flies should produce only *Cy* individuals. Unfortunately, the surviving males of the assumed $\frac{cnl_3}{cnl_3}$ genotype showed poor fertility; however, when they were crossed with females of the expected $\frac{cnl_3}{cnl_3}$ genotype, they gave no imago, although larvae formed and developed. The females of the supposed $\frac{cnl_3}{cnl_3}$ genotype, when crossed with $\frac{Cy}{cnl_3}$ males, gave only *Cy* flies. Thus, it is clear that the lethal action of the lethal allel of the *cinnabar* gene may be compensated by addition of an extract containing the cn^+ genohormone. The following fact should be emphasised. Whereas all the 558 *Cy* flies had a normal or almost normal eye colour, only a very small number of flies homozygous for the lethal survived. Of course, we are not justified to conclude from these data that the organ or cells which make the homozygotes perish, is less sensitive to the cn^+ genohormone than the eyes or ocelli. Yet, it is not altogether impossible.

The following two questions should be answered: 1) What is the reason of the cells of Malpighian tubules, eyes and ocelli showing different sensitivity to the action of the cn^+ genohormone? 2) Does the alcohol extract administered in these experiments contain one genoproduct of the normal allel of the *cinnabar* gene, or two at least? The following must be said in answer to the first question. As regards the Malpighian tubules and eyes, the difference may be apparently explained by the fact that in the Malpighian cells the cn^+ genohormone begins to accumulate and act already after 9—12 hours, which is seen from the appearance of the yellow pigment grains, while in the pigment cells of the eyes the yellowish pigment appears only in 62—70-hour-old pupae (given a temperature of 24—25° C). Till this moment no signs of pigment are to be noticed in the cells of the imaginal discs of the eyes. Therefore, when the pigment begins to form in the cells of the eyes, fresh supply of cn^+ genohormone completely or almost completely stops, and the formation of the pigment is limited by the amount of genohormone which had accumulated during the larval stage. A completely different picture is observed in the Malpighian tubules. Here the part played by the cn^+ genohormone in the formation of the pigment begins very early, when the addition of fresh genohormone continues to take place. Unfortunately, data available on the mechanics of development of the ocelli are so meagre that hardly anything can be said to explain the high threshold of excitation caused by the cn^+ genohormone. The following should be said in answer to the second question. According to Tatum and Beadle [5], the alcohol extract contains only one cn^+ genoproduct. However, it is obtained an active ethereal fraction of the cn^+ genohormone.

The method of obtaining this fraction consisted briefly in the following: dry alcohol extract of normal larvae and pupae or imago was wrapped into filter paper, placed into a Soxhlet apparatus, and treated for 20 hours with the sulphurous ether. The ethereal fraction thus obtained proved to be active. If the activity of the residue is taken for 100%, the activity of the ethereal fraction fluctuates between 15—30%. The pulp of normal larvae and pupae was treated in the same way, the ethereal fraction proved however to be inactive. This proves that the *cn*$^+$ genohormone is insoluble in ether ([5]). Consequently, an active ethereal fraction can be obtained from alcohol extract only. An active ethereal extract from an alcohol extract can also be obtained if the pulp of larvae and pupae is treated in a Soxhlet apparatus for 20 hours with sulphurous ether previous to treatment with alcohol.

At the basis of the material obtained it is so far difficult to say, whether one or two *cn*$^+$ genoproducts are present in the alcohol extract. However, the possibility of their being two is not excluded.

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GENETICS

SOME RESULTS OBTAINED BY CROSSING CULTIVATED AND WILD SUNFLOWER

By I. F. LIASHCHENKO

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When immunity of the sunflower against broom-rape and its resistance to drought was studied by us with reference to genetics in 1938, wild growing forms, *H. annuus* and *H. debilis*, obtained from the Institute of Plant Industry, were also included in the work. These species, it is true, show varying degrees of affection by broom-rape, but no strong depression of development is ever observed, and so there is ground to class them with the broom-rape resistant group.

Another character of these two wild forms is their notable drought resistance. And when in 1939 nearly all leaves on the cultivated variety were dry by the end of flowering owing to strong drought, the wild ones had their leaves in a perfect condition up to the end of the growing period. That quality of the wild sunflower is of great interest so far as synthetic selection for drought-resistance is concerned.

A characteristic feature of the wild forms is their very slow growth at early phases of development until the formation of heads. They are also 15—20 days behind the cultivated form in germination and come later to flower.

When they are crossed with cultivated selection varieties susceptible to broom-rape, resistance is dominant in F_1. But in respect to such physiological characters as rate of growth and development, as well as in respect to vigour, it is always the cultivated form that dominates in F_1, irrespective of whether it was used as the male or female parent. Similar observation has been made by Satsyperov ([1]) (*H. annuus* L. × *H. argophyllus* A. Gray).

With regard to morphological characters, both direct and reciprocal crosses between the wild and cultivated forms of *H. annuus* result in dominance of the former in F_1. It was only in one case out of seventeen that the morphological characters of the cultivated form were dominant in the first generation. In this single case the female parent was the wild variety. On the other hand, an unmistakable tendency to matrocliny was observed, while crossing *H. debilis* (wild form) with *H. annuus* (cultivated form). This phenomenon has also been reported by Platshek ([2]) in crosses between *H. macrospermus* Platshek and *H. cucumerifolius* Forr et Grag.

In 14 cases out of 17 when a wild *H. annuus* used as the male form was crossed with a cultivated *H. annuus* used as the female form and conversely, there was no segregation whatever in F_2, the entire generation consisting of wild plants. The case was similar to what had been observed by us previous-

ly in crossing cultivated forms of sunflower between one another; but what had been an exception then, now became a general phenomenon.

If the cultivated form was used as the female parent in crosses *H. annuus* × × *H. annuus*, then both the F_2 and F_1 showed all signs of the wild form. An analogous case had been described as early as 1914 by Collins and Campton (4) in intergeneric hybrids obtained by crossing *Tripsacum* with *Euchlaena*. They had found the characters of the male parent *Euchlaena* to be transmitted through three generations, and gave the name of patrogenesis to this phenomenon.

In two cases we observed a very interesting mode of inheritance. Namely, when we had crossed *H. annuus* No. 906 (wild) with *H. annuus* No. 7118J[2] (cultivated oil variety), we found the complex of wild form characters to dominate in F_1, but in F_2 all plants were of the cultivated type and there was no segregation whatever. Two such crosses were made, but the results were similar both for F_1 and F_2. Many more cases of no segregation in F_2 were recorded when this progeny was obtained from free-flowering in F_1 plants. When the cultivated form was represented in the above cross by another strain— No. 4114, raised by L. A. Zhdanov, the characters of the wild form alone appeared in F_1 and F_2.

Various cultivated selection varieties of *H. annuus* were also crossed with *H. debilis* K.1180/G.10760, and the result was that both in F_1 and F_2 only cultivated plants appeared. In other words, segregation was absent again. It may be said that here the qualities of the male parent were merged in those of the female one. Briefly the results are summarized in the adjoined table which also gives an idea about the scope of the accomplished work.

Parents	Number of crosses	Brief characteristic of F_1	Number of F_2	Brief characteristic of F_2
H. annuus (cultivated) × *H. annuus* (wild)	10	Wild form dominant	21	The complex of characters of the wild form appeared in all plants; no segregation
H. annuus (wild) × *H. annuus* (cultivated)	8	Wild form dominant in seven cases; only in one case the complex of the cultivated form characters was dominant	5	In the cross 906 × 7118 J[2] all plants reproduced the complex of the cultivated form characters; no segregation. In the cross 201 × 8281 and 6432, respectively, all plants reproduced the complex of the wild form characters; no segregation
H. annuus (cultivated) × *H. debilis*	8	Dominant was the complex of characters of the female (cultivated) parent	21	All plants bore the complex of cultivated form characters; no segregation
H. debilis × *H. annuus* (cultivated)	2	Do, but this time the wild variety had served as female parent	—	F_2 plants were not obtained

The data at hand furnish some ground for speaking of a strong absorption of the characters of the cultivated variety by those of the wild variety (within

the same species *H. annuus*) in a vast majority of cases. But if the wild form is represented in the cross by a different species *H. debilis*, its characters will not appear in the progeny, unless it is used as a maternal plant. In reciprocal crosses all its characters are suppressed.

According to some of the authors ([5]) the segregation in the second generation of hybrids obtained by crossing the cultivated species of sunflower with the wild is a very complicate picture. We, on the other hand, have observed a complete absence of segregation in the majority of cases.

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GENETICS

INDUCED DOUBLE FLOWER FORMATION IN STOCKS

By L. P. BRESLAVETZ

(Communicated by A. A. Richter, Member of the Academy, 16. X. 1940)

The purpose of this work was to furnish evidence against the current assumption (1) that it is impossible to induce double flower formation in common stocks. It seemed to us that we could fulfil our task successfully by trying, through some external influence, to obtain double-flowered specimens in a pure line of single-flowered stocks. Such a pure line in our experiment was the variety Victoria buketnaya 77 (violet) consisting of single-flowered summer plants (0% of double-flowered ones); received from O. D. Soskina. The treatment was with X-rays, with colchicine and with acenaphthene, but it is only the action of acenaphthene that is discussed in the present paper.

In March 1939 the seeds of the above-mentioned single-flower line were treated with acenaphthene according to A. A. Shmuck. As germination proceeded, the young seedlings were planted into dishes and afterwards pricked off singly into clay pots. When they had formed their first two leaves, selection was made between them to leave only those which showed changes typical of polyploid seedlings (2). Development was greatly retarded by the action of the acenaphthene and this effect was especially strong in the second planting, done in May in the same year. Taken to the greenhouse, when there was no sufficient light and heat, the plants formed flowers only in December, some of them even in March next year. Among these plants isolated double-flowered specimens were found.

All seeds from such plant families were planted separately on February 10, 1940. On account of the space available in the greenhouse, only 100 seedlings (without choice) were left from each of the experimental sets, and this number was further reduced when the plants were transferred to the hotbed. When flowers had appeared on the plants, one could easily distinguish the progeny of the acenaphthene treated seeds from the control or the colchicine set by the presence of double-flowered specimens. Their proportion varied from 41.7 to 76.1%, according to the family (Table 1).

Table 1

Treatment with acenaphthene	No. of plants	Plants		% of double-flowered
		Single-flowered	Double-flowered	
3 days	72	11	35	76.1
6 »	68	3	5	62.5
8 »	88	17	33	66.0
8 »	89	24	25	51.0
9 »	95	12	35	74.5
11 »	94	8	14	63.6
12 »	101	7	5	41.7

So, by means of the treatment of seeds with acenaphthene, we have succeeded in obtaining double-flowered specimens within a pure line of single-flowered stocks. If this phenomenon will prove reproducible, we shall find ourselves in possession of a simple method for inducing double-flowering habit in such forms, among which double-flowered plants occur only occasionally if at all. With this a fundamental change would be introduced in an important branch of horticulture.

The phenomenon is so interesting, that although little is known about it as yet, we cannot help trying to explain it here by a provisional hypothesis. Before we do this we will give a morphological analysis of the control (common single-flowered) and the double-flowered stocks (Table 2).

Table 2

Morphological Analysis of Control and Double-flowered Plants

	Control	Double-flowered
Number of shoots . . .	4	16
Number of leaves . . .	60	81
Number of flowers . . .	44	80
Number of petals in a flower	4	1) 43, 2) 48, 3) 50, 4) 51, 5) 52, 6) 55, 7) 59, 8) 61, 9) 67, 10) 75, 11) 84

Note. Averages of the data obtained for two control and two double-flowered plants.

A glance at Table 2 will reveal the great wealth of leaves, flowers and expecially petals in the double-flowered plants. This accounts for their rich, luxuriant appearance, which makes each of them look like a bunch of flowers. Besides, their flowering period is longer; the double-flowered stocks still bear flowers when the single-flowered ones, sown simultaneously, already bear nearly ripe fruits.

The inference to be drawn from the fact that our double-flowered stocks have so strongly increased in the number of petals, even if compared to the common double-flowered stock, having an average of 40 according to Soskina [3], not to mention the single-flowered with their 4 petals, is that the transformation of stamens into petals cannot possibly alone account for the appearance of the double-flowering habits. A new formation of petals mentioned by Goebel [4] must take place here. Since a very remote time stocks have been grown in the gardens of Europe, and the cultivation of their double-flowered forms can be traced as far back as to the middle of XVI century. But in spite of this, no hypothesis has been put forward to explain the origin of double flowers and no method suggested for securing the appearance of the phenomenon by horticultural means.

If, however, the literary data bearing on the subject are analyzed in the light of our observations, a general feature which has escaped the attention of previous workers, becomes obvious: double flowers appear in the progeny of those plants that have suffered retardation in their development. Has, indeed, the method of reduced watering recommended by Erfurt gardners [5] been used for the purpose, or that of Chaté, according to whom the pods are to be left on secondary shoots only [6], or again the method of delayed pollination suggested by Gärtner [7],—each of them will invariably lead to retarded flowering. In line with this falls the observation by Darwin of double flowers in *Gentiana amarella* grown on poor lime soil and of partly double flowers in *Ranunculus repens* grown on scanty clay [8]. Another confirmation is the absence of double flowers in mottled plants pointed out by Morren [9] and the change of the double flowering habit in late pricked-out plants reported by Masters [10].

In our experiment the acenaphthene caused a very strong delay in development, and some of the stocks tested came to flower only in December. It is among them that we found a few isolated double-flowering specimens. Their sister plants which had got ripe very late too, gave 46 to 76% of double-flowered plants in their progeny.

But why should a delayed development result in the formation of double flowers? The answer to this question may be found in a hypothesis put forward by Sachs ([11]) and developed by Goebel. According to this hypothesis, a petaloid formation of anthers and other parts of the flower takes place when the amount of substances accounting for the formation of petals is abnormally high. Darwin in the above-mentioned article also refers to what he describes as organic substance ([8]). Without entering into a discussion as to the nature of this substance—let it be a morphogenetic substance according to Sachs, or an organic one according to Darwin, or perhaps a flowering hormone—we shall only advance the assumption that a delayed development and retarded flowering cause it to accumulate in the flowers in excessive amounts, which cannot be used in the present generation and are transmitted to the next.

If our assumption is correct, then in the third generation of sister plants from double-flowering families the ratio of double-flowered specimens should become lower and further on keep decreasing along an extinction curve.

In our opinion the action of acenaphthene is by no means a specific one: any factor, physical, chemical, or biological may prove to have a similar effect. This does not mean, however, that we reject the possibility of a more profound action of acenaphthene, such as would affect chromosomes and be transmitted by descent. It is very probable that in our case a temporary influence of retarded development is combined with deeper hereditary changes. The cytological investigations which are now in progress will provide answers to these questions.

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GENETICS

SPONTANEOUS MUTATIONS IN THE *SCUTE*^{8} INVERSION IN *DROSOPHILA MELANOGASTER*

By B. N. SIDOROV

(Communicated by I. I. Schmalhausen, Member of the Academy, 3. VI. 1940)

The spontaneous mutation process in the *scute*^{8} inversion has been studied in the loci *yellow* and *achaete*. These loci were chosen because the *sc*^{8} males and especially the females exhibit marked somatic mosaizism for the *y* and *ach* characters. The occurrence of mosaizism in the *sc*^{8} aberration and in other analogous cases is connected with the fact that as the result of aberration the loci, showing the changes of mosaic character, become attached to the inert substance of the chromosome. Besides, I already have shown (4) that under the action of X-rays some kind of lethal changes of the *y ach* loci occur much more frequently than in the normal *X* chromosome. These lethal changes are either small chromosome rearrangements or gene mutations. In connexion with this the study of the spontaneous mutation process in these loci seemed of great importance, because it might throw light on the character of those changes which occur in the somatic tissues of flies from the *sc*^{8} stock or in the somatic tissue of flies bearing an aberration analogous with *sc*^{8}, which at the same time gives a mosaic manifestation of a given character.

The spontaneous mutation process for the *y ach* loci was studied first of all in males and homozygous *sc*^{8} females. The mutations became manifest in F_1 because the *sc*^{8} males and females were crossed with the *y sc*^{13} *w* stock containing recessive mutations of these loci. Among the progeny of the *sc*^{8} males 250366 F_1 individuals were studied, in which 44 changes of *y ach* were found (1 mutation per 5689 F_1 individuals). All *y ach* mutations were always found as single individuals and they were all lethal in homozygous condition. No *y ach* mutations were found in the progeny of the *sc*^{8} females (50725 F_1 individuals were studied). Besides *y ach* mutations eight *sc w* males were found in the progeny of the *sc*^{8} males. These males showed, moreover, some characters of the *sc*^{8} stock, viz. the *Hw* characters (microchaetes on the wings, etc.). They are obviously *y sc*^{13} *w* males whose *y ach* characters are suppressed by the normal allelomorphs of these genes from the *sc*^{8} chromosome. Further investigations showed that the *y ach* mutations and the changes causing the emergence of *y sc*^{13} *w* males with non-apparent *y ach* characters occur as the result of crossing-over between the inert substance of the distal end of the *sc*^{8} chromosome and the short arm of the *Y*-chromosome, and represent additional crossover classes. A number of proofs of the crossover nature of these changes has been obtained. First of all, it was shown that as compared to homozygous *sc*^{8} females which do not give the *y ach* mutation, females heterozygous for the *sc*^{8} chromosome and for the normal *X*-chromosome with attached short arm of the *Y*-chromosome, manifest *y ach* mutations with a frequency of 1 per 3092 chromosomes (74193 individuals have been examined). It was shown further on that the *X*-chromosome containing the

«*y ach* mutation» has a piece of the distal end of the short arm of the *Y*-chromosome on its distal end. This was proven in the following way. Males containing translocations of the short arm of the *Y*-chromosome into chromosome IV and bearing altered fertility genes, which are usually sterile (2), received sc^8 chromosomes with «*y ach* mutations» (the lethality of *y ach* was suppressed by a deletion containing normal allelomorphs of the *y ach* genes). Out of the seven «*y ach* mutations» thus investigated in six the fertility of the males containing this translocation has recovered; consequently, they possessed the distal end of the short arm of the *Y*-chromosome. Similar experiments with a translocation involving the long arm of the *Y*-chromosome gave in all cases negative results.

All the *sc w* males obtained from crossing sc^8 males with *y* sc^{13} *w* females proved sterile. Therefore, a special experiment was carried out in order to clear up the nature of this change which was searched for in females with linked *X*-chromosomes. Females with linked *X*-chromosomes containing the *y v f* genes were crossed with sc^8 males, and among their progeny several *v f* females non manifesting *yellow* gene were found. When females were crossed with *yellow* males, their progeny gave *y v f* females and grey males that proved sterile. However, when *v f* females were crossed with males bearing an *X*-chromosome with a short arm of *Y* attached to it, they gave fertile males. This experiment convincingly proves that the change under consideration represents an *Y*-chromosome whose distal end of the short arm is replaced by the distal end of the sc^8 chromosome containing normal allelomorphs of the *y ach* genes. Finally, I have shown that the males bearing both altered chromosome, i. e. an *X*-chromosome with the «*y ach* mutation» and an *Y*-chromosome with a duplication, do not differ from the usual sc^8 males. It is noteworthy that while one of the crossover classes, namely the «*y ach* mutations», arose with a frequency of 1 per 5689 flies, the additional class occurred much less often. Among the 100167 F_1 flies obtained from crossing *y v f* females with linked *X*-chromosomes with sc^8 males, only eight *v f* females were found, or one change per 12500 F_1 flies. M. E. Neuhaus (1) has described a similar difference in the frequency of emergence of additional crossover classes for crossing-over between linked *X*-chromosome and the *Y*-chromosome.

The arising of viable chromatids as a result of crossing-over between the inert substance of the distal end of the sc^8 chromosome and the short arm of the *Y*-chromosome shows, that the *X*- and *Y*-chromosomes which have undergone the exchange have in this case conjugated in an order reverse to the normal. This inverted conjugation of the *X*- and *Y*-chromosomes may be explained either by the presence in the normal *X*- or *Y*-chromosomes of a region inverted as regards the respective region from another chromosome, or by non-homologous conjugation of the *X*- and *Y*-chromosomes.

In the light of the data described in the present paper it becomes clear that the *y ach* mutations obtained in sc^8 males under the action of X-rays are, on the one hand, genuine mutations and, on the other, result from crossing-over between the *X*- and *Y*-chromosomes. This mixed character of *y ach* mutations induced by X-rays accounts for the double peak curve of the frequency of occurrence of these mutations in X-rayed sc^8 males formerly obtained by Patterson (3).

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PHYSIOLOGY

INTEROCEPTIVE CONDITIONED CONNEXIONS. FORMATION OF MOTOR INTEROCEPTIVE CONDITIONED CONNEXION FROM THE INTESTINE

By E. AIRAPETIANZ, N. VASSILEVSKAYA and A. PERELMAN

(Communicated by A.A. Ukhtomsky, Member of the Academy, 18. IX. 1940)

As a result of investigations carried out by one of the authors was established the fact of formation of conditioned reflexes from the receptive surface of the mucous membrane of the stomach. In the course of this work certain regularities of the interaction of extero- and interoceptive conditioned stimuli (1) were studied. In another work, while stimulating the mucous membrane of the stomach with a current of air and reinforcing this stimulus by an electrical current applied to the left hind-leg, a conditioned interoceptive motor reflex was produced (2).

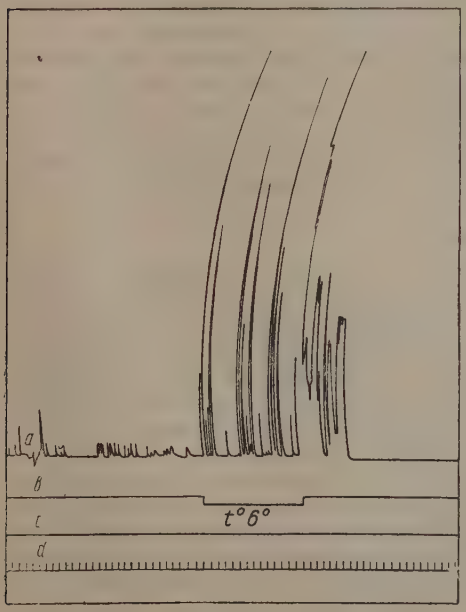

Fig. 1.

In the present communication we shall bring forth new data dealing with the formation of conditioned connexions from the receptors of the mucous membrane of the intestine.

In the dog «Bobik» the loop of bowel is separated by the Thiry-Vella method. A piece of the intestine 10 cm long cut out in the neighbourhood of the duodenum, with the nervous and vascular system kept intact, is sewn by the ends to the external surface of the skin. The loop of bowel thus isolated, retaining its normal secretory and motor functions, presents a receptor apparatus, at least of that intestinal region where it was taken from. Besides, this dog had the duct of the left parotid gland likewise separated.

Half an hour before the test a small rubber bulb is introduced into the loop of the bowel. Water at different temperature is poured into the bulb

during the experiment. The inflowing water while extending the rubber bulb transmits the corresponding temperature to the mucous membrane of the intestine. The use of water at 6—7° C was combined with the electro-cutaneous excitant on the left hind-leg. The current was used at threshold power. The reaction of the leg was recorded on a kymograph. The interoceptive conditioned reflex was formed after the combination was repeated the fourth time. But the connexion proved to be unstable, it was often vanishing or appearing now in a slight degree, now, on the contrary, very sharply pronounced. At last

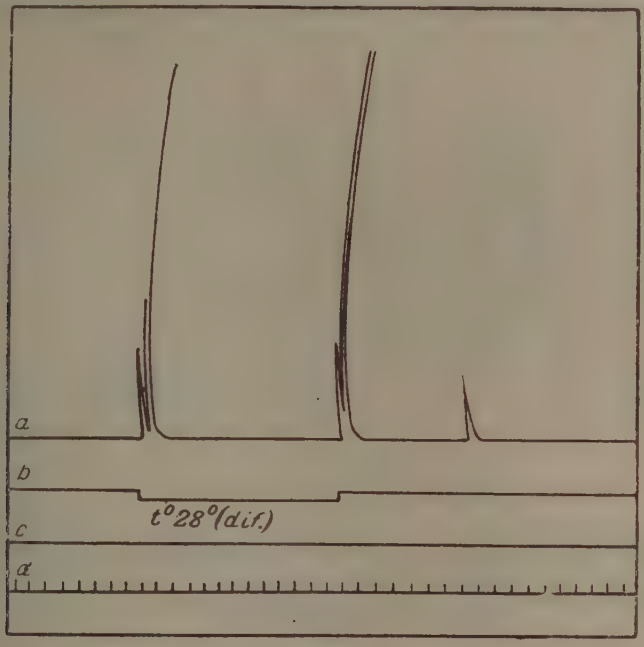

Fig. 2.

after 117 combinations the conditioned reflex became stable: the paw was accurately and unfailingly raised each time the thermal signal reached the receptor of the intestinal mucous membrane (Fig. 1).

With water temperature at 28—30° C we set to establish differentiation. The given thermal stimulation was consequently not accompanied by conditioned reinforcing. As a result of such a coincidence of stimulation of the intestinal mucous membrane, the dog reacted to cold water by lifting the paw and to warm water by withholding the motion of the paw. Differentiation is obvious (Fig. 2).

Let us analyze the curve. As shown in Fig. 2, the dog has lifted the paw twice: at the start of the inhibitory stimulus for 2—3 seconds and at its cessation. These reactions are not incidental. Under the conditions of our experiment the interoceptive stimulus presented a complex of two successive components: one of mechanical contact with the intestinal mucous membrane (during expansion) and that of temperature. The flow of water was started with the mechanical expansion of the rubber bulb, and only within a few seconds the receptor seemed to be receiving two different signals: that of cold or warm water, excitation or inhibition. This is precisely the way in which the chain of vectors of the cortical analysis was revealed in the experiment above: a) excitation from the mechanical stimulus and b) depending upon

the temperature applied—at 6—7° C continuation of the process of excitation, at 28—30° C instantaneous change to inhibition. As to the lifting of the paw upon cessation of the inhibitory stimulation, this is a result of non-differentiated reaction, strongly and stably connected with the moment of reinforcing, i. e. with the application of the electric current as the reinforcement of the positive cold stimulus (6—7° C). This connexion persisted when the temperature was 26° C, however for one instant only (2″—4″ and 2 motions of the paw), whereas after actual reinforcing (in the dog «Bobik»)

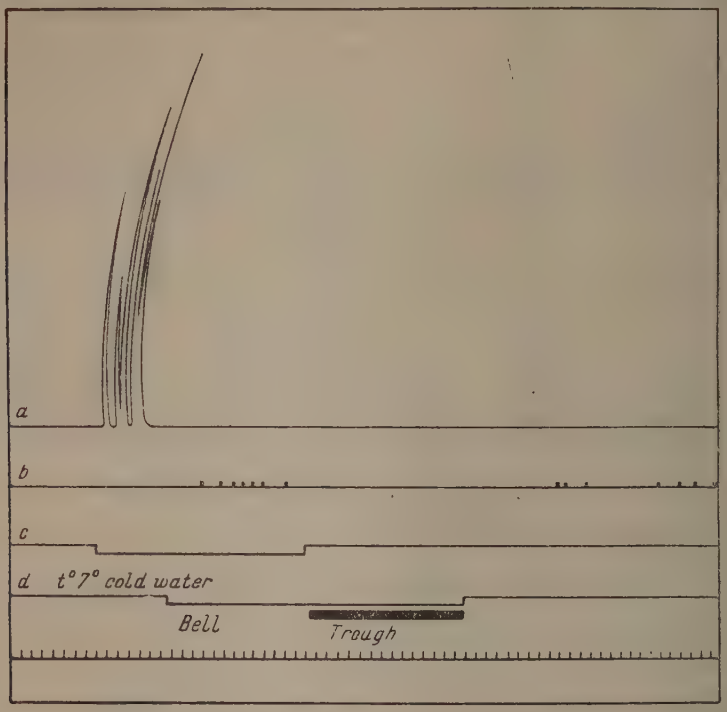

Fig. 3.

the motor reaction was always violent and lasting. In this case, however, as may be seen from the curve, after 2 «erroneous» motions of the foot followed quiescence.

In this series of investigations we performed special tests on interaction in the cerebral cortex of conditioned reflexes based on impulses proceeding from the outside and from internal organs. The dog has developed, besides the interoceptive conditioned reflex already described, a number of exteroceptive conditioned (food and motor) reflexes, in particular, conditioned saliva-secretion expressed in 5—7 drops of saliva following isolated action of the bell. Thus, the dog develops two kinds of conditioned reflexes: the one interoceptive to the thermal stimulus of the intestinal mucous membrane (the rubber bulb with water at 6—7° C) in the intestine reinforced by the electro-cutaneous stimulation of the left hind paw, the other—exteroceptive, to the sound of the bell reinforced by the food stimulus. In the former case the starting mechanism of the cortex of the cerebral hemispheres started operating from the intestine and resulted in a motor reaction, in the latter case it started from the ear resulting in salivary secretion. Action is initiated by the

interoceptive conditioned stimulus (without reinforcing). There is an immediate response in the lifting of the leg. Within 7—8 sec. we switch in the bell: the motion of the foot stops, saliva-secretion ensues, in spite of the fact that the conditioned stimulus of the receptive surface of the intestine is still operative. The effect of this new confronting is such that the dog seems to «halt» in the assumed posture; it listens intently to the sound of the bell, while from the salivary fistula saliva is dropping. Here we have a characteristic picture of conjugated inhibition when a dominant is present ([3]). This is all the more interesting, for it throws light on the mechanism of concomitant reactions, since the action of the bell alone has never produced any such strain of muscles or such distinct food response. (Fig. 3).

Conclusions. The stimulation of the intestinal mucous membrane by I. P. Pavlov's method of temporary connexions can be transformed into a conditioned signal for defensive reaction. The differentiation in the response to temperature variation which sets in upon stimulation of the intestinal mucous membrane, along with similar data obtained from experiments on the mucous membrane of the stomach, testify to the existence of an interoceptive analyzer. In the case of co-existence in the cortex of the cerebral hemispheres under definite conditions, of an exteroceptive (bell) and an interoceptive (thermal stimulation of the intestinal mucous membrane) conditioned reflectory activity, the latter undergoes depression following the mechanism of conjugated inhibition when a dominant is present.

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ECOLOGY

ON THE INVERSE RELATION BETWEEN ACQUIRED AND INHERENT PROPERTIES OF ORGANISMS

By G. F. GAUSE and W. W. ALPATOV

(Communicated by I. I. Schmalhausen, Member of the Academy, 18. X. 1940)

In studying the differences between various races belonging to the same species, or between similar species of the same genus, it can be recorded that the stronger are their inherent properties in some specific respect, the less they are capable to strengthen these properties under the effect of environmental factors. The existence of inverse relation between the acquired

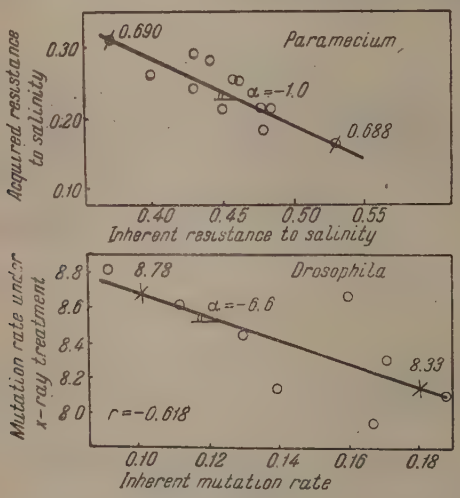

Fig. 1.

and inherent properties of organisms can be brought into relation with the general property of living systems known as compensation. Geoffroy St. Hilaire realized already, that with increase of some organs the other decrease. Rensch (1) mentioned recently several such examples. In these cases the compensation is due to a redistribution of the limited amount of matter in a biological system. It is highly remarkable therefore that there exist compensatory relations between acquired and inherent properties in such biological systems as a species or a genus.

Fig. 1 shows the relation between the inherent resistance to salinity and that acquired in the process of acclimatization, in various races of infu-

soria *Paramecium caudatum* ([2]). The acquired resistance is distinctly inversely proportional to inherent resistance: [acquired] $=l-\alpha$ [inherent]. The coefficient of inverse proportionality (α) in this case is equal to unity. This case can be considered as an example of complete compensation: the deficiency of inherent resistance is compensated by the acquired resistance in such a way that the total of these two properties is maintained approximately the same within the limits of the species. But it is also often observed ([2]) that $\alpha>1$ (in the rapid acclimatization of paramecia to increased salinity $\alpha=3.6$ and to quinine solutions $\alpha=2.2$). These cases can be considered as an incomplete inverse proportionality between acquired and inherent properties or, in other words, as a non-proportional compensation. The inherently weaker races evidently overcompensate their weakness, and in respect of the total resistance they exceed inherently stronger ones.

The inverse relation between acquired and inherent resistance to arsenic in different races of infusoria *Colpoda steini* is clearly seen from the figures reported by Schuckmann ([3]), although the author himself did not notice this regularity.

It is of interest to point to the inverse relation between inherent mutation rate and that induced by X-rays in various races of *Drosophila melanogaster*. Timofeeff-Ressovsky ([4]) concluded that these characters are not correlated with each other. However, when we plot his own figures on a graph (Fig. 1), the inverse relation between both variables becomes quite conspicuous. The coefficient of correlation between the inherent and acquired mutation rates $r=0.618$, and having six degrees of freedom we can with the certainty of 90 chances out of 100 accept the existence of this inverse relation. The coefficient α calculated by the method of least squares equals—6.6. Here again slightly mutable races overcompensate their weakness, and by the total (induced + inherent) mutation rate exceed those which are inherently more mutable (8.78 against 8.33). As far as in the light of the data published by Demerec ([5]) the observations of Timofeeff-Ressovsky are not entirely comparable, having been made within a period of several years, it seems desirable that geneticist would repeat them in special experiments designed for that purpose. If confirmed, the process of mutation could be brought under the general principle of inverse relation between inherent and acquired properties of organisms.

One more example is the inverse relation between the inherent number of erythrocytes in blood of different species of mice belonging to the genus *Apodemus*, and the number of erythrocytes acquired under the effect of decreased barometric pressure ([6]). In this system, as in those mentioned earlier, the acquired properties are inversely proportional to inherent ones.

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PFLANZENPHYSIOLOGIE

ASSIMILATION DES STICKSTOFFS DER KNÖLLCHEN DURCH DIE LEGUMINOSEN

Von M. ALI-SADE

(Vorgelegt von A. A. Richter, Mitglied der Akademie, den 16. X. 1940)

In der vorhergehenden Arbeit (1) haben wir gezeigt, dass bei Leguminosen der von Knöllchenbakterien fixierte Stickstoff unmittelbar ausgenützt werden kann, indem er aus den Knöllchen in andere Organe geleitet wird. Es war von Interesse den Mechanismus dieses Stickstofftransport-Prozesses aufzuklären. Als Ursache einer solchen Bewegung des Stickstoffs aus den Knöllchen in die oberirdischen Organe, betrachten wir die in den Knöllchen vor sich gehenden proteolytischen Prozesse, obwohl es Korsakowa und Lopatina (2) nicht gelungen ist, in der von ihnen untersuchten Leguminosenpflanze die Proteolyse in den Knöllchen zu beobachten.

Wir stellten uns zur Aufgabe die proteolytischen Prozesse in den Knöllchen zu erforschen. Um exakte Resultate bei dieser Untersuchung zu erzielen, beschlossen wir den Vorlauf der Proteolyse nach den Entwicklungsphasen der höheren Pflanze zu verfolgen, was in der Arbeit von Korsakowa und Lopatina (2) nicht berücksichtigt wurde. 1937 und 1938 wurden von uns Vegetations- und Laboratoriumversuche angestellt. Die Technik der Vegetationsversuche ist in der vorhergehenden Arbeit beschrieben (1). Als Versuchspflanze wurde gelbe Lupine gewählt.

Auf Grund der Arbeiten von Mothes(4, 5), Smirnow (6) und anderer Forscher, kamen wir zum Schluss, dass in der jüngeren Entwicklungsphase vor der Blütenknospenbildung und Blüte, die Pflanzen ein weniger aktives Vermögen zur Proteolyse aufweisen, in der späteren Phase aber—zur Zeit der Fruchtbildung—der Prozess der Proteolyse aktiv verlaufen muss. Deshalb wurden die Knöllchenproben für die Versuche in 3 Terminen genommen: zur Zeit der Blütenknospenbildung, zur Zeit der Blüte und während der Fruchtbildung. Frische Knöllchen wurden sofort nach Abtrennen von der Pflanze in einem Porzellanmörser bis zu halbflüssiger Konsistenz zerrieben. Dann wurden von dieser Masse 0.5—1.0 g in ein Reagenzglas gebracht, 10 cm^3 destilliertes Wasser und 0.5 cm^3 Toluol hinzugesetzt. In den Versuchen, die zur Aufklärung der Wirkung des Saftes aus Blättern von Pflanzen verschiedenen Alters aufgestellt wurden, wurde in jedes Reagenzglas noch eine bestimmte Menge Saft hinzugefügt. Der Saft wurde in folgender Weise hergestellt: es wurden Blätter, etwa von der Mitte des Stengels, in dem Mörser zerrieben, und die erhaltene Flüssigkeit durch eine doppelte Schicht Gazestoff durchgelassen.

In den Reagenzgläschen der Kontrolle wurde Anfangsgehalt an Eiweissstickstoff bestimmt. Die Reagenzgläschen des Versuches wurden auf eine bestimmte Zeit entsprechend dem Versuchsschema bei 29° in den Thermostat gestellt. Nach Beendigung des Versuches wurde ebenfalls der Gehalt an Eiweisstickstoff nach Barnstein bestimmt.

Versuch 1. Zerriebene Knöllchenmasse+10 cm³ destilliertes Wasser+0.5 cm³ Toluol. Eiweisstickstoff in % des Rohgewichtes der Knöllchen (Tabelle 1).

Tabelle 1

Versuchsdauer	Knöllchen von den Pflanzen während der Blütenknospenbildung abgetrennt		Knöllchen während der Blüte von den Pflanzen abgetrennt		Knöllchen während der Fruchtbildung von den Pflanzen abgetrennt	
	N in %	Differenz in % von der Kontrolle	N in %	Differenz in % von der Kontrolle	N in %	Differenz in % von der Kontrolle
0 (Kontrolle) . .	1.07	100.0	1.23	100.0	1.26	100.0
1 Tag	1.17	109.3	1.19	94.4	0.92	73.0
2 Tage	1.22	114.0	0.87	78.8	0.96	76.1

Wie oben erwähnt, wurde der Eiweisstickstoff nach Barnstein bestimmt. Während der Blütenknospenbildung der höheren Pflanze herrschen die synthetischen Prozesse über die Proteolyse vor. Der Gehalt an durch Kupferhydroxyd ausfällbaren Stickstoff hat in diesem Fall in zwei Tagen um 14% zugenommen, während wir in den späteren Entwicklungsphasen der Pflanze das umgekehrte Bild beobachten. In der Knöllchenmasse hat während des Blühens und der Fruchtbildung die ausfällbare Stickstofform während 2 Tagen um 27% abgenommen.

Somit wurde festgestellt, dass in der frühen Entwicklungsperiode der Pflanze während der Blütenknospenbildung in den Knöllchen keine proteolytischen Prozesse stattfinden. Uns interessierte die Frage, ob dies vom Alter der Pflanzen oder von ihren Entwicklungsphasen abhängt. Zu diesem Zwecke wurden während der Blütenknospenbildung zwei Gruppen junger gleichaltiger Pflanzen, die nach Wuchs und Entwicklung einander nahestanden, ausgewählt. Von den Pflanzen der einen Gruppe wurden dann alle erscheinenden Blütenknospen entfernt, die Pflanzen der zweiten Gruppe entwickelten sich normal. Nach 20-tägigem Entfernen der Blütenknospen wurden die Pflanzen beider Gruppen geerntet. Die Knöllchen wurden von den Wurzeln abgetrennt, und Versuche zur Untersuchung der Proteolyse angestellt.

Tabelle 2

Versuchsdauer	Knöllchen abgetrennt von Pflanzen mit entfernten Blütenknospen		Knöllchen abgetrennt von Kontrollpflanzen	
	N in %	Differenz	N in %	Differenz
0 (Kontrolle) .	1.07	100.0	1.26	100.0
1 Tag	1.15	107.4	0.92	73.0
2 Tage	1.32	123.3	0.96	76.1

Versuch 2. Zerriebene Knöllchenmasse+100 cm³ destilliertes Wasser+0.5 cm³ Toluol. Stickstoff nach Barnstein in % des Rohgewichtes der Knöllchen (Tabelle 2).

Obgleich die Knöllchen in beiden Fällen von gleichalterigen Pflanzen genommen wurden, waren die proteolytische Prozesse ganz verschieden gerichtet. Durch dieses Ergebnis werden wir veranlasst uns zu den allgemeinen Begriffen über die Abhängigkeit der Prozesse des Wachstums und der Entwicklung zu wenden. Wie von T. D. Lyssenko festgestellt wurde, sind die Wachstums- und Entwicklungsvorgänge nicht identisch.

Wie unsere Versuche zeigen, begünstigen wir, indem wir die Phase der Blütenknospenbildung der Lupine verlängern, die Richtung der proteolytischen Prozesse, die der Phase der Knospenbildung eigen sind. Auf Grund der erhaltenen Resultate können wir nicht behaupten, dass in der Phase der Blütenknospenbildung oder in den Knöllchen der «kastrierten» Pflanzen keine Proteolyse stattfindet. Das wäre unrichtig, da in jedem Organismus sich auf jeder Entwicklungsstufe Prozesse des Zerfalls und der Synthese der Eiweisstoffe vollziehen. Aber durch Bestimmung der Veränderung der Eiweisstoffe bei Autolyse können wir auf das Vorherrschen des einen von diesen Prozessen schliessen.

Wenn während der Blütenknospenbildung in den Knöllchen keine Zunahme der ausfällbaren Stickstofformen festgestellt wird, so bedeutet das nicht, dass in den Knöllchen gar keine Zerfallsprozesse stattfinden. Parallel mit der Synthese können Zerfallsprozesse vor sich gehen, aber in so geringem Umfange, dass die Prozesse der Synthese diejenigen der Proteolyse übertreffen.

Die oben angeführten Versuchsergebnisse deuten auf eine Zunahme der durch $Cu(OH)_2$ ausfällbaren Stickstofformen in den Knöllchen der «kastrierten» Pflanzen. In den Knöllchen der sich normal entwickelnden Pflanzen jedoch, die sich zur Zeit der Abtrennung der Knöllchen in der Phase der Fruchtbildung befanden, herrschte der Eiweisszerfall über der Synthese vor, und schon in den ersten 24 Stunden findet eine Abnahme des Eiweissstickstoffes statt. Was die Stoffe, die durch Kupferhydroxyd gefällt wurden, anbetrifft, so können wir, da keine eingehenden Untersuchungen über diese Frage vorliegen, nichts positives aussagen. Eine analoge Zunahme der ausfällbaren Stickstofformen fand sich in den Versuchen von Kostytschew und Brilliant ([3]).

Die Veränderung der Richtung der Proteolyse in den Knöllchen in Abhängigkeit von den Entwicklungsphasen der Pflanze kann unter dem Einfluss von Stoffen, die von der Pflanze produziert werden, erfolgen. Schulze ([7]) hat in seiner umfassenden Arbeit den Einfluss von solchen Stoffen auf den Vorgang der Proteolyse in der zerriebenen Blattmasse festgestellt. Er hat beobachtet, dass der Extrakt aus Blättern verschiedenen Alters, sogar verschiedener Höhenlage, nicht in gleichen Weise auf die Richtung der proteolytischen Prozesse einwirkt.

Wir nehmen an, dass durch das Pflanzenalter bedingte, oben festgestellte Veränderungen in der Richtung der proteolytischen Prozesse können durch Veränderungen der Blätter entsprechend ihrem Alter, die die Knöllchen sowohl mit Nahrstoffen (Zuckern), als auch mit Regulatoren der proteolytischen Systems versorgen, erklärt werden. Zur Prüfung dieser Hypothese ist von uns eine Reihe von Versuchen über die Wirkung des Blattsaftes auf die Proteolyse in der Knöllchenmasse ausgeführt worden. Es wurden Versuche angestellt, deren Technik oben beschrieben ist, nur mit dem Unterschied, dass zu dem Gemisch aus zerriebenen Knöllchen, Wasser und Toluol noch Blattsaft hinzugesetzt wurde. Die Methode der Saftbereitung ist oben beschrieben.

V e r s u c h 3. Proteolyse in den Knöllchen von fruchttragenden Pflanzen. Zerriebene Knöllchenmasse + 10 cm^3 destilliertes Wasser + 0.5 cm^3 Toluol. Stickstoff nach Barnstein in % des Rohgewichtes der Knöllchen (Tabelle 3).

Wie oben dargelegt, zeichnen sich die Knöllchen der fruchttragenden Pflanzen durch aktive proteolytische Prozesse aus. In dem vorliegenden Versuch haben wir unter dem Einfluss des Blattsaftes von «kastrierten», d. h. jüngeren, Pflanzen den Prozess der Proteolyse in den Knöllchen etwas gehemmt.

Tabelle 3

Versuchsdauer	2 cm³ Saft aus Blättern von kastrierten Pflanzen		2 cm³ Saft aus Blättern von fruchttragenden Pflanzen	
	N in %	Differenz	N in %	Differenz
Vor dem Versuch .	1.61	100.0	1.67	100.0
1 Tag	1.36	84.4	1.11	70.7

Versuch 4. Proteolyse in den Knöllchen von blühenden Pflanzen. Stickstoff nach Barnstein in % des Rohgewichtes der Knöllchen (Tabelle 4).

Tabelle 4

Versuchsdauer	Ohne Saft		0.5 cm³ Saft aus Blättern von Pflanzen während der Blütenknospenbildung		0.5 cm³ Saft aus Blättern von fruchttragenden Pflanzen	
	N in %	Differenz	N in %	Differenz	N in %	Differenz
Vor dem Versuch .	1.30	100.0	1.49	100.0	1.56	100.0
2 Tage	1.22	93.8	1.62	104.0	1.24	79.0

Die Ergebnisse zeigen uns, dass in den Knöllchen, die während der Blüte von den Pflanzen abgetrennt wurden, bei Bedingungen der Autolyse ein Zerfall des Eiweisses stattfindet. Genauer formuliert, herrschen in den Knöllchen in der erwähnten Entwicklungsphase der Pflanze die Zerfallsprozesse (bei Bedingungen der Autolyse) über den synthetischen Prozessen vor, jedoch sind die Veränderungen, die während 2 Tagen auftreten, unbedeutend.

Ausserdem wird durch vorliegenden Versuch die verschiedene Wirkung des Saftes aus Blättern, die von den Pflanzen in verschiedenen Entwicklungsphasen abgetrennt wurden, auf die proteolytischen Prozesse in den Knöllchen festgestellt. Der Saft aus Blättern, die während der Blütenknospenbildung abgetrennt wurden, hemmt die Proteolyse. Es wird sogar eine gewisse Zunahme der ausfällbaren Stickstofformen während 2 Tagen beobachtet. Der Blattsaft von fruchttragenden Pflanzen beschleunigt die Proteolyse. Während in den Knöllchen ohne Hinzufügen von Saft die Abnahme des ausfällbaren Stickstoffs 6.2% betrug, erreichte sie bei Zusatz des Saftes aus Blättern von fruchttragenden Pflanzen 20.6%. Folglich hat sich bei Hinzufügen dieses Saftes der Eiweisszerfall in den Knöllchen fast um das dreifache verstärkt.

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PFLANZENPHYSIOLOGIE

ZUR FRAGE ÜBER DAS VORHANDENSEIN VON GEBUNDENER AMYLASE IN DEN CHLOROPLASTEN

Von L. NEZGOVOROV

(Vorgelegt von A. A. Richter, Mitglied der Akademie, 26. IX. 1940)

Die Frage über freie und gebundene Amylase des Blattes wurde am Ende des vorigen und zu Beginn dieses Jahrhunderts eingehend behandelt.

Nachdem in der vorhergehenden Mitteilung (1) gezeigt wurde, dass in den Chloroplasten nur sehr wenig freie Amylase vorhanden ist, setzten wir unsere Untersuchungen zur Aufklärung der Frage, ob nicht gebundene Amylase in den Chloroplasten enthalten ist, fort. Die Methode der Isolierung der Plastiden, die Bestimmung der Verzuckerungsaktivität der Amylase blieben dieselben (1).

Auf das Freiwerden der Amylase bei Autolyse der Gewebe haben, ausser Palladin und Popoff (1922), auch K. Myrbäck und seine Mitarbeiter (2, 3), Chrzaszcz und Janicki (4) hingewiesen.

Die Autolyse der Suspension von Plastiden haben wir parallel bei 18—20° und bei 40—42° C, mit Zusatz eines Gemisches von Toluol und Chloroform als Antiseptikum ausgeführt. Die Ausgangsproben auf Amylase und Stickstoff wurden 30—60 Min. nach Bereitung der Suspension entnommen. Der lösliche Stickstoff wurde nach Kjeldahl nach Entfernung der Plastiden durch Zentrifugieren in 7 cm^3 Filtrat bestimmt. Es muss hervorgehoben werden, dass die der Autolyse untergezogene Suspension, die aus ganzen Plastiden und deren Granulae bestand, ihre ursprünglich grüne Färbung während der ganzen Versuchsdauer fast unverändert beibehielt. Nur beim Aufbewahren der Suspension über einen Monat verblasste die grüne Färbung und an ihre Stelle trat eine braune auf, die Flüssigkeit aber über den Plastiden färbte sich dabei nicht. Die Versuchsergebnisse mit der Autolyse der Plastiden sind in Tabelle 1 angeführt.

Dass die Autolyse wirklich stattgefunden hat, zeigt die gesetzmässige Zunahme der löslichen Stickstoffmenge. Die Aktivität der Amylase nimmt dabei etwas zu und fällt dann wieder ab. Manchmal aber wird eine Veränderung der Aktivität nicht beobachtet. Die bei einigen Pflanzen auftretende ziemlich auffallende Abnahme der Aktivität der Amylase bei Autolyse bei 42° kann durch Wärmeinaktivierung des Fermentes erklärt werden.

Parallel mit der Autolyse wurde in einigen Versuchen, um eine tiefgreifendere Zerstörung der Eiweisskörper zu erzielen, die Behandlung mit Pepsin vorgenommen, da nach Angabe von Lepeschkin (5) Pepsin bei dauernder Einwirkung sogar Nuklein zu zerstören vermag. Für das Vorhandensein von Nukleoproteiden in den Plastiden sprechen die physikalischen Beobachtungen

Tabelle 1

Aktivität der Amylase bei Zerfall des Eiweisses (in 10 cm³ *n*/10 J auf 10 g Blätter; löslicher Stickstoff in mg auf 10 g Blätter)

		Amylase	Lösl. N	Amylase	Lösl. N	Amylase	Lösl. N	Amylase	Lösl. N
Triticum vulgare	Dauer in Tagen	0		1		5		24	
	Autolyse bei 20°	0.5	1.9	—	—	1.9	—	1.5	3.4
	» bei 42°	0.5	1.9	—	—	1.0	—	1.9	4.6
	» mit Pepsin bei 42°	0.5	1.9	1.9	3.3	1.0	6.6	—	6.7
Avena sativa	Dauer in Tagen	0		2		10			
	Autolyse bei 20°	0.3	1.0	—	1.5	0.6	2.3		
	» bei 42°	0.3	1.0	—	—	0.6	4.0		
	» mit Pepsin bei 42°	0.3	1.0	—	2.6	1.3	3.9		
Avena sativa II	Dauer in Tagen	0		5		12		21	
	Autolyse bei 20°	0.21	1.8	0.64	—	0.5	—	—	3.8
	» bei 42°	0.21	1.8	0.5	3.6	0.8	3.7		
Agropyrum repens	Dauer in Tagen	0		3		16			
	Autolyse bei 22°	0.98	1.8	0.9	1.8	1.17	4.9		
Phaseolus vulgare	Dauer in Tagen	0		2		3			
	Autolyse bei 20°	1.17	—	1.7	—	—	—		
	» bei 42°	1.17	1.1	0.31	4.0	0.43	3.9		
Phaseolus vulgare II	Dauer in Tagen	0		2		13			
	Autolyse bei 20°	0.88	1.9	1.1	—	—	3.6		
	» bei 42°	0.88	—	0.4	—	0.2	—		
	» mit Pepsin bei 42°	0.88	2.1	0.5	5.4	—	—		
Trifolium pratense	Dauer in Tagen	0		2		7		14	
	Autolyse bei 20°	2.57	1.1	3.16	—	3.16	1.5	2.7	1.6
	» bei 42°	2.57	—	0.74	2.2	—	—	0.7	2.5
	» mit Pepsin bei 42°	1.85	1.1	0.6	3.0	—	—	—	
Allium cepa	Dauer in Tagen	0		3		15			
	Autolyse bei 20°	0.2	1.9	0.1	—	0.1	3.0		
	» bei 42°	0.2	1.9	0.1	3.1	—	—		
Arcticum tomentosum	Dauer in Tagen	0		1		2		14	
	Autolyse bei 40°	1.75	—	—	—	—	—	1.35	—
	» mit Pepsin bei 40°	1.5	—	0.3	2.3	0.3	2.6	0.3	3.3

von Menke ([6]) (über die Lichtbrechung) und frühere Angaben über die chemische Zusammensetzung der Chondrisomen ([7]). Die Befürchtungen von Myrbäck, dass der Amylasenträger durch Pepsin zerstört werden könnte, sind wohl unbegründet, denn die Versuche von Akabori und Okahara([8]) sprechen gegen seine Eiweissnatur und für seine Beständigkeit gegenüber proteolytischen Fermenten. In unseren Versuchen haben wir 10 cm³ 3% Pepsinlösung in 1% Salzsäure zu 100 cm³ mit Essigsäure angesäuerter Plastidensuspension hinzugefügt. Die Menge des löslichen Sticktoffs war dabei (Tab. 1) um 1.5—2 Mal grösser als bei der gewöhnlichen Autolyse. Seine Zunahme geht hauptsächlich in den ersten 1—2 Tagen vor sich, was in vollkommener Übereinstimmung mit der Annahme über das Vorhandensein von Nukleoproteiden in den Plastiden steht. Die Aktivität der Amylase wurde in der Suspension nach ihrer Neutralisierung mit Soda und nachfolgendem Hinzufügen von 10 cm³ $^1/_{15}$ M Phosphatpuffer mit Ph=4.9 bestimmt. Die in der Tabelle 1 angeführten Zahlen zeigen, dass wir bei der Pepsinverdauung des Eiweisses keine bedeutende Zunahme der Aktivität der Amylase vorfinden, sondern im Gegenteil nicht selten sogar ihre Abnahme

beobachten. Die Abnahme der Aktivität der Amylase bei der Pepsinverdauung der Eiweisse in unseren Versuchen und in den Versuchen 1935 von Chrzaszcz und Janicki (4) oder sogar ihre vollkommene Inaktivierung muss man wahrscheinlich mit dem langen Verweilen der Extrakte bei erhöhter Azidität in Zusammenhang bringen.

Versuche mit Autolyse der Plastiden gestatten den Schluss zu ziehen, dass in den Plastiden aktive Protease vorhanden ist. Diese Frage wurde nicht speziell untersucht.

1936 haben Chrzaszcz und Janicki (4) gezeigt, dass Schwefelwasserstoff, ebenso wie auch Pepton, zu einer Gruppe von Stoffen gehören, die die Fähigkeit besitzen spezifische Aktivatoren der Amylase frei zu machen und zwar in einer nicht geringeren Menge wie Papain. In der vorhergehenden Mitteilung (1) haben wir gezeigt, dass das Hinzufügen von Pepton keine Zunahme der Aktivität der Amylase in den Plastiden hervorruft. Analoge Resultate erhielten für die Getreidekörner K. Myrbäck und S. Myrbäck (3).

Die Verwendung von Schwefelwasserstoff in unseren Versuchen wurde, abgesehen von der Anschauung von Chrzaszcz und Janicki, noch dadurch veranlasst, dass in den Plastiden Schwermetalle in freiem und in mit organischen Stoffen gebundenem Zustand vorhanden sind, speziell Kupfer (9), welches als ein Hemmungsfaktor der Amylasereaktion erscheinen kann (10). Bei Behandlung der Extrakte mit Schwefelwasserstoff werden die Schwermetalle ausgefüllt und dadurch ihre hemmende Wirkung beseitigt.

Der Behandlung mit Schwefelwasserstoff wurde eine wässerige Suspension der Plastiden (1 : 10) unterzogen. Das vorher gereinigte Gas wurde während 1—2 Stunden durch die Suspension geleitet; falls die Einwirkungsdauer verlängert werden sollte, wurden die mit Schwefelwasserstoff behandelten Plastiden in der verschlossenen Kolbe in einer Atmosphäre von H_2S bis zur Probeentnahme stehen gelassen. Zur Bestimmung der Amylase wurde der Überschuss an Schwefelwasserstoff entweder durch Stehenlassen der offenen Kolben mit den behandelten Plastiden an der Luft oder durch Hindurchleiten während einiger Zeit eines Stickstoffstromes durch die Suspension, entfernt.

Tabelle 2

Aktivität der Amylase bei Behandlung mit Schwefelwasserstoff (in cm^3 $n/10$ J auf 10 g Blätter)

Plastiden von	Dauer der H_2S Behandlung in St.	Nicht behandelt	Behandelt mit H_2S	Differenz
Triticum vulgare . .	22	0.65	0.5	−0.15
Avena sativa	3	0.27	0.6	+0.33
	80	0.60	1.1	+0.5
Phaseolus vulgaris .	2	1.17	0.81	−0.36
Trifolium pratense . .	14	2.57	2.60	+0.03
Allium cepa	2	0.17	0.13	−0.04
	18	0.20	0.11	−0.09
Arctium tomentosum .	2	1.4	1.24	−0.16
	24	1.4	1.08	−0.32
Agropyrum repens . .	18	0.5	0.82	+0.32
Hordeum vulgare . .	22	0.16	0.16	0

Die Ergebnisse der Bestimmungen des Verzuckerungsvermögens der Amylase in den mit Schwefelwasserstoff behandelten Plastiden sind in Tabelle 2 angeführt; sie zeigen eine schwache Aktivierung der Amylase oder sogar ihre Depression.

Wir sehen, dass sogar die maximale Zahlen der Aktivität der Amylase nach Autolyse der Plastiden und ihrer Behandlung mit Schwefelwasserstoff viel kleiner sind, als diejenigen der Aktivität der Amylase des Zytoplasmas und des Zellsaftes. Es können also die Resultate der vorhergehenden Mitteilung (1) über den unbedeutenden Gehalt der Plastiden an freier Amy-

lase durch Ergebnisse über den geringen Gehalt der Plastiden an gebundener Amylase oder sogar ihre Abwesenheit ergänzt werden. Der äusserst geringe Gehalt der Plastiden an Amylase, sowie auch die Herstellung von Plastidenpräparaten aus *Hordeum vulgare*, die in einigen Fällen frei von Amylase waren, lässt überhaupt bezweifeln, ob die von uns bestimmte Amylase den Plastiden selbst angehört, oder ob sie infolge der Unvollkommenheit unserer Methode der Isolierung der Plastiden aus dem Zytoplasma stammt. Jedenfalls stellt die Tatsache der äussersten Armut der Plastiden an Amylase ihre Beteiligung an der Stärkesynthese aus den primären Produkten der Photosynthese in Zweifel. Eine Aufklärung anderer Möglichkeiten dieser Synthese ist erforderlich.

Suchorukov und Nezgovorov ([11]) haben auf das Vorhandensein eines stärkesynthesierenden Fermentes (labile Systoamylase) in den Kartoffelknollen hingewiesen, das nach seinen Eigenschaften an die von anderen Autoren entdeckten stärkesynthesierenden Fermente erinnert, aber mit der Amylase nichts gemein hat. Es ist die Möglichkeit nicht ausgeschlossen, dass auch in den Plastiden die Stärkebildung von dem Vorhandensein eines amylosynthesierenden Fermentes abhängt. Einen verwandten Standpunkt über die Umwandlung der Stärke in der Zelle nimmt Hanes ein ([12]).

Das Vorfinden der Amylase vorzugsweise ausserhalb der Plastiden macht die Annahme wahrscheinlich, dass die Hydrolyse der Stärke in der CO_2 assimilierenden Plastide durch Einwirkung der Amylase des Zytoplasmas vor sich geht. Das gibt uns die Möglichkeit eine der Abhängigkeiten der arbeitsfähigen Plastiden von dem Zytoplasma und seinem Zustande zu begreifen.

Die Arbeit wurde unter Leitung von K. Suchorukov, Professor der Universität Tomsk, ausgeführt.

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EVOLUTIONSMORPHOLOGIE

EINIGE ANGABEN ÜBER ANZEICHEN PARTHENOGENETISCHER ENTWICKLUNG DER *CASPIALOSA VOLGENSIS*

Von S. G. SOYN

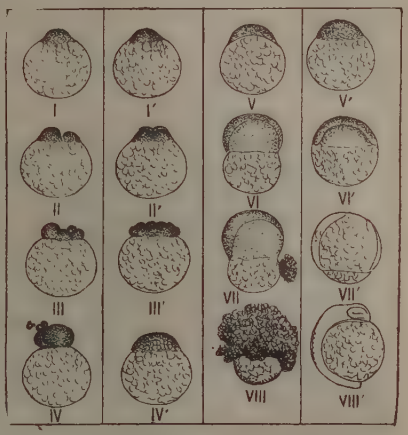
(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 19. IX. 1940)

Die Untersuchung der parthenogenetischen Entwicklung der Fischeier hat ausser theoretischem Interesse auch grosse praktische Bedeutung. Um die Prozentzahl der befruchteten Eier festzustellen, ist es für die Praxis der künstlichen Fischzucht wichtig zu wissen, nach welchen Anzeichen man schon auf frühen Stadien der Embryonalentwicklung den befruchteten Laich von dem unbefruchteten unterscheiden kann. Das Fehlen solcher Kenntnisse führte dazu, dass die meisten Fischzüchter, indem sie als Anzeichen der Befruchtung beim Fischlaich die Quellung der Eihülle annahmen, falsche Angaben über die Resultate der künstlichen Befruchtung erhielten, denn eine solche Quellung findet in gleichem Grade bei befruchtetem, wie auch bei reifem unbefruchtetem Fischlaich statt. Deswegen war auch der Grad der künstlichen Befruchtung fast immer mit ungefähr 100% geschätzt. Wie aber eine Reihe von Untersuchungen zeigten [A. N. Trifonowa (1931), W. Kazansky (1925), T. E. Morosowa (1936)], beginnt der unbefruchtete reife Laich, nachdem er ins Wasser kommt, sich ebenfalls «parthenogenetisch» zu entwickeln. Dabei sind einige seiner Entwicklungsstadien, der äusseren Struktur nach, in gewissem Grade den Entwicklungsstadien des befruchteten Laichs ähnlich.

Wir haben in ganz allgemeinen Zügen die «Entwicklung» des unbefruchteten Laichs von *C. volgensis* untersucht und eine Gegenüberstellung mit der normalen Entwicklung des befruchteten Laichs vorgenommen. Für diesen Zweck wurde der reife Laich, welcher von dem Weibchen *C. volgensis* genommen wurde, in zwei Portionen geteilt. Eine von ihnen war mit der «trocken» Methode befruchtet, und die andere blieb unbefruchtet. Beide Portionen des Laichs wurden mit einer kleinen Wassermenge in Petrischalen gebracht. Die Temperatur schwankte während der Beobachtungszeit zwischen 17—19° C. Die Beobachtungen wurden gleichzeitig ausgeführt, wobei die entsprechenden Zeichnungen angefertigt wurden.

Zum Vergleich müssen wir zuerts kurz einige Stadien der Entwicklung des befruchteten Laichs von *C. volgensis* beschreiben. Der Laich von *C. volgensis* ist pelagisch, im Wasser quillt er sehr schnell an. Zwischen dem Ei und seiner Hülle bildet sich ein grosser Raum, der dem Laich gestattet sich in schwebendem Zustand in der Wasserströmung zu halten. 45 Min. nach der Befruchtung beginnt an dem animalen Pol der einzelnen Fischeier die Konzentrierung des Keimplasmas in der Form

eines Hügelchens und bildet die sogenannte Keimscheibe (Abb. *I*). Diese Keimscheibe beginnt nach einer Stunde 15 Min. nach der Befruchtung mit der Furchung und bildet alle 30 Min. im Durchschnitt die 4—8—16—32 Blastomeren (Abb. *II'*, *III'*). Als Folge dieser Furchung bildet sich in 6 Stunden nach der Befruchtung eine aus vielen Blastomeren bestehende Haube, wo die einzelnen Blastomeren noch unter der Lupe zu unterscheiden sind—dies ist die sogenannte frühe Morula (Abb. *IV'*). Bei der weiteren Furchung bildet sich die späte Morula (Abb. *V'*), deren Blastomeren schon schwer unter der Lupe zu unterscheiden sind. Danach (11 Stunden nach der Befruchtung) folgt das Stadium der Blastula. Dann beginnt der Gastrulationsprozess (Abb. *VI'*, *VII'*), welcher, dank der starken Zellvermehrung an den Urmundlippen des Blastoporus, von einer Verschiebung des Blastoderms von dem animalen Pol auf den vegetativen Pol begleitet ist. Während dieses Prozesses geht die Differenzierung des Blastoderms zu ihren einzelnen Keimblättern—Ekto-, Endo- und Mesoderma vor sich, aus denen sich die Anlagen der einzelnen Organe des Keimes herausdifferenzieren. Es bildet sich das Nervenrohr, die Chorda, das Darmrohr und einige andere Organe. Auf solche Weise ist in 26 Stunden nach der Befruchtung, bei einer Temperatur des Wassers von 17—19° C, der Keim in den Hauptzügen formiert (Abb. *VIII'*).



I und *I'*—die Konzentration des Keimplasmas an dem animalen Pol; Alter 45 Min. *II* und *II'*—die Furchung der unbefruchteten Eier in 2 und der befruchteten Eier in 4 Blastomeren; Alter 1 St. 45 Min. *III* und *III'*—die Furchung der unbefruchteten Eier in 4 und der befruchteten Eier in 16 Blastomeren. *IV*—die Hervorhebung und Ablösung des Plasmas vom unbefruchteten Ei. *IV'*—das Stadium der frühen Morula; Alter 6 Stunden. *V*—das Zerfliessen des gebliebenen Plasmas über dem animalen Pol des unbefruchteten Eies. *V'*—das Stadium der späten Morula; Alter 8 St. *VI*—das zerfliessende Plasma umfasst die Hälfte des Eies. *VI'*—das Anfangsstadium der Gastrulation; Alter 13 St. *VII*—weiteres Zerfliessen des Plasmas und beginnende Zerstörung des Eies. *VII'*—späteres Stadium der Gastrulation; Alter 21 St. 30 Min. *VIII*—weitere Zerstörung des Eies. *VIII'*—Embryo mit einem Augenbecher; Alter 29 St.

Während dieser Zeit durchläuft der unbefruchtete Laich eine besondere und zwar eine parthenogenetische Entwicklung. Ähnlich wie der befruchtete Laich beginnt er im Wasser zu quellen, und an dem animalen Pol der parthenogenetischen Eier konzentriert sich, ebenfalls in der Form eines Hügelchens, das Keimplasma (Abb. *I* und *I'*), was in diesem wie jenem Fall gleichzeitig vor sich geht. Somit ist es in diesem Stadium unmöglich den befruchteten Laich von dem unbefruchteten zu unterscheiden. Danach setzt bei den meisten unbefruchteten Eiern ebenfalls eine Art Furchung ein, und es bilden sich dabei 2, 4 und sogar noch mehr Blastomeren (Abb. *II* und *III*), was ebenfalls eine Unterscheidung des unbefruchteten Laichs von dem befruchteten erschwert. Bei einer genaueren Untersuchung jedoch kann man sich überzeugen, dass die «Blastomeren» des unbefruchteten Laichs gleich zu Beginn der Furchung, der Grösse nach ungleich sind und oft eine unregelmässige Form haben (Abb. *II*, *III* und *IV*). Ausserdem geht der Furchungsprozess bedeutend langsamer vor sich, als bei dem befruchteten Laich. So furchen sich z. B. die unbefruchteten Eier in zwei «Blastomeren», während in gleicher Zeit der befruchtete Laich schon ein Stadium

von vier Blastomeren erreicht hat (Abb. *II* und *II'*); zu der Zeit, wo die Furchung der unbefruchteten Eier vier Blastomeren erreicht, besitzen die befruchteten schon 16 Blastomeren (Abb. *III* und *III'*). Danach erleidet der unbefruchtete Laich starke Veränderungen. Die Keimscheibe beginnt sich stark hervorzuheben, was zu ihrer Loslösung an den einzelnen Stellen führt. Dies geschieht zu der Zeit, wo die befruchteten Eier ein Stadium von 32—64 Blastomeren erreicht haben (Abb. *IV* und *IV'*), und dauert fort bei Stadium der später Morula, d. h. während 5 Stunden seiner Entwicklung. Diese Zeit ist am bequemsten für die Bestimmung der Prozentzahl der befruchteten Eier. Auf diesem Stadium der Entwicklung ist es möglich mit grosser Leichtigkeit sogar mit einer einfachen Lupe die Zahl der befruchteten und unbefruchteten Eier festzustellen, um auf solche Weise das Verhältnis zwischen ihnen zu bestimmen. Nachdem treten in der Entwicklung des unbefruchteten Laichs wieder solche Veränderungen auf, welche dem äusseren Aussehen nach in bestimmten Grad den Stadien ähneln, die zu dieser Zeit die befruchteten Eier durchlaufen. Nachdem sich bei den unbefruchteten Eiern ein Teil des Keimplasmas abgeschnürt hat, beginnt das gebliebene Plasma allmählich am animalen Pol zu zerfliessen und bildet eine Haube, welche dem Äusseren nach der Haube der späten Morula ähnlich ist. Da aber die Blastomeren der befruchteten Eier im Stadium der späten Morula sehr klein sind und die Grenzen schwer zu unterscheiden sind, so ist es auch in diesem Fall sehr leicht den unbefruchteten Laich als befruchteten anzunehmen (Abb. *V* und *V'*). Schwer sind sie auch in den nächstfolgenden Entwicklugsstadien zu unterscheiden. Mit dem Beginn der Gastrulation der befruchteten Eier, d. h. von dem Moment an, wo der Dotter vom Blastoderma umwachsen wird und seine Einstülpung ins Innere vor sich geht, kann ebenfalls wieder ein ähnlicher Prozess bei den unbefruchteten Eiern beobachtet werden. Das Keimplasma des unbefruchteten Eies zerfliesst weiter auf dem Dotter und bedeckt ihn fast zur Hälfte, imitiert auf solche Weise das Bild der wirklichen Gastrulation (Abb. *VI* und *VI'*), wodurch es für den nicht geübten Forscher schwer ist den unbefruchteten Laich von dem befruchteten zu unterscheiden.

Mit diesem Prozess schliesst die «parthenogenetische» Entwicklung der unbefruchteten Eier ab. Von diesem Moment an gehen die unbefruchteten Eier massenweise zu Grunde, was durch den Durchbruch des den Dotter umgebenden Plasmas begleitet ist. Dies führt dazu, dass die Dottermasse nach aussen fliesst und das Ei dadurch zerstört. Dieser Prozess beginnt, wenn die befruchteten Eier die Gastrulation beenden (Abb. *VII'*) und währt bis zu ihrem Augenbecherstadium (Abb. *VIII'*).

Auf solche Weise versucht der unbefruchtete reife Laich von *C. volgensis* im Verlauf von 29 Stunden bei einer Temperatur von 17—19° C sich parthenogenetisch zu entwickeln und geht danach zu Grunde.

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EXPERIMENTAL MORPHOLOGY

DOES THYROTROPIC HORMONE CAUSE REFRACTORINESS IN BIRDS?

By P. A. WUNDER, Z. V. POMELTSOVA and K. G. WIEBE

(Communicated by I. I. Schmalhausen, Member of the Academy, 15. IX. 1940)

Development of refractoriness and of a specific immunity to hormones have been described by numerous authors. In this respect the work by Miller(1) on sparrows is of particular interest. On the basis of data obtained Miller arrives at a conclusion that birds in general fail to develop immunity to the thyrotropic factor, i. e. that not necessarily all vertebrates become refractory to hormones of protein nature.

We decided to check this conclusion by experiments on chicks which are known to be the most suitable objects for tests with thyrotropic hormones. In 1939 and 1940 experiments were carried out with two sterile extracts from the anterior pituitary of man and cattle. Hypophyses dehydrated by acetone and reduced to powder were extracted with 0.1 *N* $NaHCO_3$, then neutralized and sterilized by filtering through Seitz's filter. Now let us summarize the results.

1. In the test performed in the summer of 1939 the chicks were given daily, except on the free days, subcutaneous injections of the extract from human hypophyses, in single doses of 0.5 cm^3 =6.5 mg of pituitary powder. The treatment was carried over a period of 31 days. On the 32nd day the chicks—both the experimental and control ones—were sacrificed, the thyroid glands weighed and histologically examined. The results of the experiment show that on the 32nd day of thyrotropic treatment the thyroid glands reached the quiscent stage, practically not differing in any way from the thyroids of the control chicks. There is evidence of complete refractoriness to the action of the thyrotropic hormone.

2. In order to investigate more closely how the glands are brought back to normal, a special test was performed in 1940. This time the extract from ox pituitaries was used. As distinguished from the former test, the extract was administered continuously twice a day. The daily dosage of extract was 1 cm^3, 10 mg equivalent of pituitary powder. After various periods of hypophyseal treatment the chicks were killed and their thyroid glands examined. At the same time control chicks of corresponding age were subjected to study.

The experiment has shown that already on the 19th day of administration of the hypophyseal extract the thyroid glands histologically come near to normal. On the 32nd day of the test the height of the epithelium of the

experimental chicks equals (to be exact, it is even slightly below) the height of the epithelium in the controls. This is evidence of refractoriness to the hormone. However, as distinguished from the first experiment with human hypophysis, the thyroid glands of the chicks under experiment after 29—31 injections differed greatly in weight from those in the controls (the difference amounting to 40%). Thus, according to their histological structure, the thyroid glands on the 29—31 day of the experiment maintained a state of quiescence, though differing in size from the glands of the control specimens. Consequently it is the histological structure rather than the weight of the glands that should be used as evidence for or against the phenomenon of refractoriness.

This conclusion is quite in accord with the data on the persistence of the thyrotropic reaction after the hormone administration has been discontinued. In one of our experiments the glands having reached the weight of 9 mg after 5-day administration of ox pituitary extract, have after a lapse of 30 days still exceeded considerably (by 69%) the weight of thyroids in normal chicks, whereas histologically the glands returned to normal 15 days after the cessation of hormone treatment.

What is the nature of refractoriness to the thyrotropic hormone in chicks? And does it depend upon the production of antihormones?

Testing the blood serum of chicks which have received thyrotropic treatment for 31 days, shows that the serum has the ability of neutralizing completely the effect of the thyrotropic hormone. Whereas the blood serum of the normal control chicks of the same age shows no inhibitory properties against it.

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PARASITENKUNDE

NEUE *DACTYLOGYRUS*-ARTEN *(TREMATODA)* AUS DEM DNJEPR

Von MARIA MALEVITSKAJA

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 19. VIII. 1940)

Während der im 1936 und 1939 zwecks der Erforschung der Fischtrematodenfauna in verschiedenen Bezirken des Dnjeprgebiets unternommenen Expedition ist von der Verfasserin eine grosse Anzahl Fischsaugwürmer gefunden worden, unter denen fünf *Dactylogyrus*-Arten sich als bis jetzt nicht bekannt erwiesen haben. Da die Bearbeitung des ganzen gesammelten Trematoden-Materials mit einem grossen Zeitaufwand verbunden sein wird, hält es die Verfasserin für zweckmässig schon jetzt eine kurze Mitteilung über die neuen Arten zu geben.

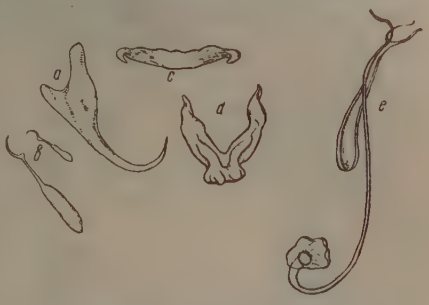

Abb. 1. *Dactylogyrus bicornis*; *a*—mittlere Haken, *b*—Randhaken, *c*—Dorsalfortsatz, *d*—ventrales Verbindungsstück, *e*—Kopulationsapparat.

1. *Dactylogyrus bicornis* n. sp. An den Kiemen von *Rhodeus sericeus* (Pallas) aus der Umgegend von Kiew und Dnjepropetrowsk gefunden. Die Länge des fixierten Tieres beträgt 0.24—0.32 mm. Der Haftapparat besteht aus 2 Mittelhaken, 2 Verbindungsplatten und 14 Randhaken. Die Gesamtlänge der Mittelhaken erreicht 0.032—0.035 mm; der Dorsalfortsatz ist ca 0.009—0.013 mm lang; der Ventralfortsatz 0.003—0.004 mm; der

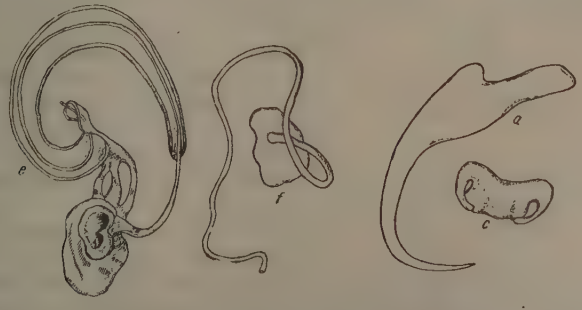

Abb. 2. *Dactylogyrus chondrostomi*. Wie Abb. 1; *f*—Vaginalbewaffnung.

Basalteil ungefähr 0.024—0.026 mm und die Hakenspitze ca 0.003—0.005 mm lang. Die dorsale Chitinplatte ist etwa 0.025—0.026 mm lang. Die ventrale

Chitinplatte hat eine sehr eigenartige Form. Sie besteht aus dem breiten Basalteil, von dem zwei Fortsätze ausgehen. Die Gesamthöhe dieses Gebildes erreicht 0.019—0.022 mm, die Breite des Basalteiles ca 0.006—0.008 mm, der Abstand zwischen den Spitzen der Fortsätze beträgt 0.019—

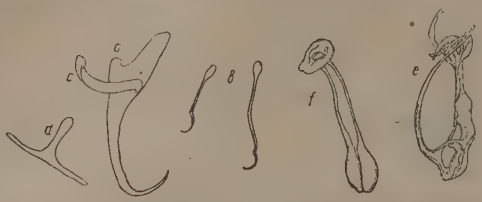

Abb. 3. *Dactylogyrus ramulosus*. Wie Abb. 1.

0.022 mm. Die Randhaken 0.017—0.029 mm sind lang und typisch gebaut. Das Kopulationsorgan ist 0.058 mm lang. Dieses Gebilde besteht aus einem trichtenförmig beginnenden Chitinrohr, und aus dem kurzen Stützteil (0.032 mm lang), der mit zwei hakenförmigen Fortsätzen endet. Die Vaginalbewaffnung fehlt (Abb. 1).

2. *Dactylogyrus chondrostomi* n. sp. Diese Art kommt an *Chondrostoma nasus* vor. Die Länge der fixierten Würmer beträgt 0.4 mm. Die Mittelhaken der Haftscheibe sind 0.048—0.055 mm lang. Die Länge des Dorsalfortsatzes beträgt ungefähr 0.016—0.019 mm, diejenige des Ventralfortsatzes 0.003 mm, die des Hakenteils 0.037—0.042 mm, die der Hakenspitze etwa 0.013—0.014 mm. Die Verbindungsplatte ist 0.019—0.022 mm lang und 0.011 mm breit; sie ist mit zwei langen Fortsätzen versehen. Die Randhaken haben fast gleiche Länge (0.019—0.022 mm). Das Kopulationsorgan ist sehr kompliziert gebaut. Von einem massiven Basalteil geht eine gebogene Rinne ab, die breit an ihrem Anfang und am Ende etwas verdünnt ist. Am Basalteil beginnt das Chitinrohr, es tritt umbiegend in die Rinne ein und öffnet sich auf der Höhe der Verbindung der Rinne mit dem Basalteil. Die Länge des ganzen Komplexes hängt von seiner Krümmung ab. Ein stark gewundenes Chitinrohr, das an einem Ende verbreitet ist, befindet sich am äusseren Rand des Receptaculum seminis (Abb. 2).

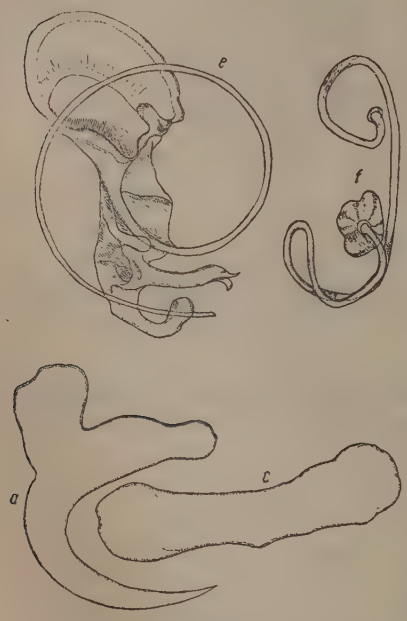

Abb. 4. *Dactylogyrus robustus*. Wie Abb. 1.

3. *Dactylogyrus ramulosus* n. sp. Diese Art ist an den Kiemen von *Leuciscus idus* in der Nähe von Kiew vorgefunden worden. Die Länge der fixierten geschlechtsreifen Würmer, die im Winter angetroffen worden sind, beträgt 1.5 mm. Die Eiablage wurde in der ersten Hälfte März beobachtet; zu gleicher Zeit wurden in grosser Menge die jungen, sehr kleinen unreifen *D. ramulosus* angetroffen. Die Länge des Mittelhakens der Haftscheibe schwankt von 0.035 bis 0.039 mm, die des Dorsalfortsatzes von

0.009—0.01 mm, die des Ventralfortsatzes von 0.003—0.004 mm, die des Basalteils von 0.026—0.029 mm, die der Hakenspitze 0.009—0.013 mm. Das dorsale Chitinstück ist 0.026—0.029 mm lang. Das ventrale Chitinstück ist seiner Form nach demjenigen von *Dactylogyrus propinquus* (Bychowsky) ähnlich. Seine Höhe beträgt 0.009—0.013 mm. Die Randhaken sind an der Grösse fast gleich (0.019—0.022 mm). Der Kopulationsorgan besteht aus einem kleinen Basalteil, von dem der verästelte Stützteil und das dünne Chitinrohr abgehen. Die ganz eigentümlich gebaute Vaginalbewaffnung erreicht eine Länge von 0.029—0.035 mm (Abb. 3).

4. *Dactylogyrus robustus* n. sp. Parasitiert an den Kiemen von *Leuciscus idus* und *Aspius aspius* im Bezirke des Deltas und des Dnjeprmittellaufs. Die Länge der bei der Fixierung sehr verkürzten Würmer erreicht 1 mm. Die Höhe der Mittelhaken beträgt 0.045—0.048 mm, die Länge des Dorsalfortsatzes ist 0.029×0.016—0.019 mm, die des Ventralfortsatzes ungefähr 0.016—0.019×0.013—0.016 mm. Die Verbindungsplatte erreicht die Länge von 0.074—0.087 mm, die Breite von 0.016—0.019 mm. Die Randhaken haben ungleiche Länge (0.026—0.039 mm). Der Kopulationsapparat besteht aus dem erweiterten Basalteil, von dem der massive Stützteil und ein Chitinrohr, welches bei seinem Umbiegen einen Kreis bildet, abgehen. Die Entfernung zwischen den äusseren Punkten dieses Komplexes schwankt von 0.084 bis 0.094 mm. Am äusseren Rand des Receptaculum seminis befindet sich ein gewundenes Chitinrohr, das an einem Ende etwas erweitert ist (Abb. 4).

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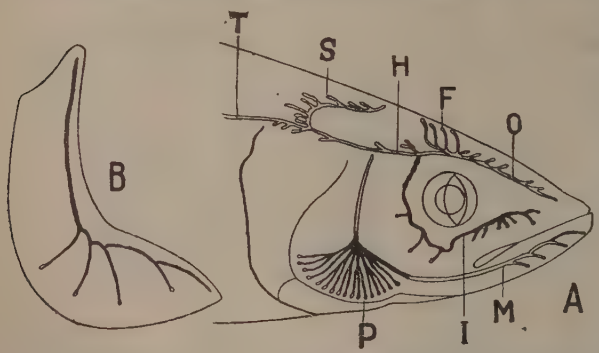
ZOOLOGY

SEISMOSENSORY SYSTEM IN *SCOMBRICIDAE*

By D. K. TRETIAKOV, Member of the Ukrainian Academy

The *Scombricidae* fishes have relatively narrow canals of the seismosensory system. In the tunny, for instance, their disproportion with the common dimensions of the trunk is striking. Besides this, they are partly deeply immersed in the bones of the cranium. All this presents considerable technical difficulties for studying them by means of injection. The most accessible are the infraorbital seismosensory canal and the preopercular part of the hyomandibular. The other canals have to be investigated combining Allis' method which he applied as early as 1903, examining the thin bones in the passing light of a magnifier and studying the canals on series of cuts.



A—reconstruction of the seismosensory canal on the head of *Scomber*; *B*—preopercular bone in *Sarda sarda* with the outer canaliculi and a part of the inframaxillar canal; *F*—suprafrontal outer canaliculi; *H*—postorbital canal; *I*—infraorbital canal; *M*—hyomandibular canal; *O*—supraorbital canal; *P*—preopercular outer canaliculi; *S*—supratemporal branch; *T*—trunk canal at the place where it changes into the temporal canal.

Applying all the indicated methods I was able to give a fuller idea of the seismosensory canal systems in *Scomber scomber* L. and *Sarda sarda* C. V., than Allis had done. The hyomandibular canal penetrates farther than the other canals into the anterior part of the head in *Scomber* (figure, *M*). It sends off four outer canaliculi into the anterior part of the mandibula, but the canal itself runs along the longitudinal axis of the mandibula in its fungous bony mass under the mandibular cartilage. There are no outer canaliculi along the further extent of the canal, until it passes over to the anterior margin of the preopercular bone; but where the horizontal part of the canal changes into an ascending one almost at a right angle, 17 lengthened and branched outer canaliculi go off at the midheight of the preopercular bone (figure, *P*). Disposed fan-like, they all open with their pores near the posterior and the lower margin of the bone. Almost throughout their length the canaliculi run in the fungous mass of the preopercular bone, each having

its own bony wall. But closer to the outer pore the outer canaliculus is adjacent to the outer plate of the preopercular bone and then coalesces with it by its bony wall. Finally, passing out through the bony plate the bony canaliculus changes into a short skinny canaliculus with an outer pore. The seismosensory canal runs vertically upwards in the upper part of the preopercular bone, slightly bending in the thickening of the bead of the outer bony wall. In this part there are no outer canaliculi. Losing near the upper bone margin its bony wall, the canal terminates blindly in the skin and has the appearance of a short process; it terminates on the level of the postorbital canal without fusing with the latter.

The postorbital canal runs onward until the supraorbital and the infraorbital canals unite. The former reaches the area of the anterior margin of the nasal cavity where it opens by its anterior outer canaliculus (figure, *O*). Here the supraorbital canal is included into the outer plate of the comparatively thin nasal bone. Two more outer canaliculi run from the anterior outer canaliculus to the anterior nasal aperture.

The frontal bones in *Scomber* are considerably thickened, particularly in their mesial part, and consist of a fungous mass of thin bony cross-beams, the mass is included between the outer bony plates. The lower plate is even on the side that covers the brain cavity of the cranium, the upper plate is porous and uneven. The supraorbital canal passing from the nasal bone into the frontal one, is adjacent with its bony wall to the lower bony plate and runs over it being deeply imbedded under the whole fungous mass. There are about three regularly disposed outer canaliculi in this section, too.

Over the anterior part of the lens the supraorbital canal sends off a short outer canaliculus that runs laterally, as the preceding ones, and a long mesial canal running vertically to the skin of the dorsal side of the head. The mesial canaliculus runs from the surface of the bone till the deep layer of the skin in the thick part of the fat tissue, at first turning under the skin in a mesial direction. Penetrating into the skin and losing its very thin bony wall, the mesial canaliculus turns sharply backwards to its outer pore. A short mesial branch starts from the supraorbital canal directly behind the mesial canaliculus; this branch sends off to the dorsal side of the head from three to four mesial outer canaliculi with a thin bony wall on each of them. Thus, on the whole there is formed a group of eight or ten long, outer suprafrontal canaliculi (figure, *F*).

This group penetrates to the dorsal side of the head through the fatty band that fills, over the frontal bones, the interspace between the right and the left myotomic musculature over the posterior part of the skull. In some specimens of *Scomber* the pores and sections of skin of the suprafrontal canaliculi are well seen in fresh fish; they have the appearance of two short, light strips lying in two rows converging backwards. Owing to the ramification of the skin sections of the suprafrontal canaliculi, the number of pores amounts to 9—10. Both rows are disposed near the mid-dorsal line of the head.

The supraorbital canal itself running over the orbit gets somewhat widened and swerves to the lateral side; it approaches the base of the frontal bone crista that is covered with a myotomic musculature. The posterior part of the canal enters the crista and runs out of it into the deep layer of skin, sending off a short outer canaliculus with from two to three branchlets and pores. In this very place the supraorbital canal joins the infraorbital.

The latter running along the surface of the postorbital bones under the transparent tissue of the posterior cushion of the lid (1) bends round the orbital margin, sending off three outer canaliculi from the lower part of its arch. They reach the margin of the cushion and here they open with their pores

outwards. The parts of the chief canal between the mentioned canaliculi have the appearance of arches turned by their concavity frontward. Before entering the preorbital (lacrymal) bone, the canal becomes more curved. The infraorbital canal immersing into the fungous mass of the bone, runs to its anterior end sending off 6—7 outer canaliculi. They all open with their pores on midheight of the preorbital bone. The postorbital seismosensory canal (*H*) immerses again into the above-mentioned rib of the intermuscular crista of the frontal bone; the canal runs in the open trench of the frontal bone crista that gets soon closed. The canal, widening a little, swerves to the base of the crista.

The postorbital canal has a short outer canaliculus at the place where the blind process of the hyomandibular canal approaches the postorbital one. The further part of the canal that runs backwards over the upper margin of the opercular bone is to be considered a temporal canal. It has a narrowed lumen and runs into the posttemporal bone out of the mentioned bony crista; this crista runs on along the pteroticum (according to Allis, the squamosum); in the *Scombricidae* this bone is of considerable length.

A branch, as wide as the seismosensory canal itself, starts from it in the middle part of the posttemporal bone and its seismosensory canal; the branch arches and runs upward and frontward to the dorsal side of the head (figure, *S*). The anterior end of the branch changes into an outer canaliculus that turns to the side of the middle line of the head, but does not reach it. Three or four canaliculi more follow it running backwards. The other four or five canaliculi start from the posterior side of the lower arch of the indicated supratemporal branch, the middle one of these canaliculi exceeds the other in length. The whole branch is inclosed in a thin bony wall that is the prolongation of the posttemporal bone. The pores of all these canaliculi as well as those of the four canaliculi that start off from the temporal canal downwards through the exterior plate of the posttemporal bone, are well seen on the lateral surface of the head over the upper margin of the gill cover. Their canaliculi form the supratemporal group. Thus, the lateral surface of the head over the gill cover bears numerous pores of the outer canaliculi.

The seismosensory temporal canal abandoning the posttemporal bone changes into the trunk canal covered with small scales; each of them has a pronounced bony canaliculus. The ripple, that is formed of the wall of the canaliculus, runs along two thirds of the length of the scale and sometimes reaches its posterior ridge. On the trunk the number of outer canaliculi and their pores is very considerable.

The seismosensory canals on the head of *Sarda* show in the main the same plan of distribution, at the same time there are some specific peculiarities. The nasal bone in *Sarda* is relatively thicker than in *Scomber*. The supraorbital canal, having adopted the most anterior outer canaliculus, runs along the longitudinal axis of the bone in the depth of its fungous mass. But over the olfactory nipple the canal approaches the exterior bony plate and over the posterior ridge of the nipple it comes to the surface of the skin in the shape of a short, ascending outer canaliculus.

The mesial part of the frontal bone is composed of an entire bony plate, whereas the lateral part is thickened and comprises the fungous bony mass. The supraorbital canal passes into it out of the nasal bone and sends off a long outer canaliculus over the anterior margin of the orbit. Opposite the centre of the cornea a mesial branch starts from the canal and arches to the skin through the fibrous band. The fibrous band, deprived of fatty tissue, lies among the myotomic musculature. The branches of the right and the left side join forming the suprafrontal commissure; the outer canaliculus, with a pore on the middle line of the head, starts from the top of the commissure.

In young *Sarda* with dark, transverse stripes of the skin there is a fibrous band. In the adult *Sarda*, that has got longitudinal stripes, the suprafrontal commissure is entirely included in the frontal bones that form the middle keel of the skull.

The supraorbital canal behind the commissure swerves sharply to the side of the skin; it sends off into the skin outer canaliculi: a short one directed upwards and then a long one directed downwards. The supraorbital canal joins the infraorbital one in the interspace between the crista of the pteroticum and the supratemporal bone. A short outer canaliculus starts from the upper end of the infraorbital canal, and another canaliculus runs horizontally through the thick fibrous layer along the brim of the lid from the place, where the arched posterior part of the canal turns to its anterior horizontal section.

The infraorbital canal, running onwards in the preorbital bone, sends off three more outer canaliculi and terminates in a fourth anterior one sooner than the supraorbital canal.

The temporal canal running in the posttemporal bone sends off in its middle into the skin a wide branch where it ramifies into two outer canaliculi, a horizontal one and another that ascends obliquely to the dorsal side of the head.

The postorbital and temporal canals, compared to those in *Scomber*, are shortened before the temporal canal enters the posttemporal bone; a part of the temporal canal in this bone is elongated.

Like in *Scomber* the hyomandibular canal passes in the dental bone with the same number of outer canaliculi, but in the lower part of the preopercular bone the number of elongated canaliculi (figure, *B*) is no more than four, and the upper end of the canal does hardly reach the margin of the preopercular bone.

The system of outer canaliculi in *Sarda* is, in general, simpler than in *Scomber*; in the tunny it is still more simplified, but the main seismosensory canals of the head have in tunny the same disposition as in *Sarda*. Taking into consideration that in *Scomber* and in *Trachurus trachurus* there is a repeatedly expressed tendency to form elongated and numerous outer canaliculi on the dorsal side of the head (Tretiakov, 1938), it is necessary to consider the indicated particuliarities of the system of seismosensory canals in the *Scombricidae* as typical for the whole group of *Scombriformes*, and the morphology of this group thus becomes enriched with new symptoms.

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HYDROBIOLOGY

BACTERIAL PROFILE OF MARINE SEDIMENTS AS AN INDEX OF THEIR EROSION AND AGE

By E. DIANOVA and A. VOROSHILOVA

(Communicated by W. I. Vernadsky, Member of the Academy, 6.VIII.1940)

Hereafter will be presented some data obtained from bacteriological investigations of the bottom deposits in Caspian Sea and of littoral grounds in the gulf of Kola. These date furnish a good illustration to the relation between the bacterial profile of a ground and the history of its formation. They also place a bacteriological criterion at the base of our judgment about the comparative age of the marine deposits concerned and the direction of their growth.

Conclusions on the vertical distribution of bacteria in the grounds investigated are inferred mainly from the occurrence there of bacteria of the saprophyte group. If a ground is spoken of as sterile because it contains no saprophytic bacteria, this, of course, does not mean that it is absolutely free from any other bacteria. Sterility is here a conventional term.

We have chosen saprophytic bacteria for the following reasons: 1) they bear witness of the ageing process from the moment when the deposits were thrown down until their complete mineralization; 2) among this group there are many sporiferous species which can hold traces of subsequent stages in the ground ageing; 3) they are widely spread in nature; 4) the methods of studying them are simple and convenient.

In water basins the distribution of bacteria across the bottom deposits is essentially dependent on three spatial factors: 1) distance from the store, 2) from the water surface, 3) from the surface of the ground.

In the littoral zone, where algae and higher plants are usually richly developed and where organic matter is carried to from the shores, there is an abundant inflow of organic material. As the depth here is not considerable, the whole mass of organic matter dying off has no time for disintegration while on its way to the bottom. But farther away from the shores, as the depth increases, the sea bottom is less and less provided with decomposable remains, because the income and production grow lower, while the extent of decomposition in the material which has not yet reached the bottom grows higher.

Accordingly, the layer of mud formed by sedimentation of organic matter from water is thicker near the shores than in deeper regions of the sea. To this distribution of the organic material in the ground is necessarily adapted the distribution of saprophytic bacteria, for which ground is the nutrient substratum. In fact, there have been made indications in literature that the content of bacteria in the superficial layer of the ground keeps decreasing in the direction away from the shore ([5],[6]). And at great depths (1500—5000 m) no bacte-

ria at all have been found in this layer ([3],[4]). Data on the vertical distribution of bacteria in various horizons of the sea bottom bear similar evidence. Here, too, the bacteria are decreasingly abundant towards greater depths ([1],[2]).

A different relation could hardly be expected indeed, after it has been established that in the superficial layer of the ground the quantity of bacteria shows a steady decrease with increasing depth to become zero at the bottom of the ocean. It is only natural to infer from this that their penetration into the thickness of sea grounds follows the same law.

So we come to the following picture of bacterial distribution in sea grounds: the bacteria decrease in number with their penetration deep down into the bottom, or further off into the sea where depths are greater. When we follow them deep enough into the ground—just how deep depends upon the composition of the deposits and the rate of their formation—we find there no living cells of bacteria (saprophytes) any more, and then the spores, too, disappear. Now the ground is sterile. Near the shore we have to go a big way to reach the sterile horizon, but its distance from the surface of the bottom decreases as the distance from the shore increases.

This is the normal picture of bacterial distribution across the bottom deposits. It is observed only in the absence at the bottom of dynamic processes which could have caused a translocation of deposits—their washing out or drifting in. Every transfer of the deposits in a horizontal direction brings with it a redistribution of the organic material in them, which necessarily results in a departure of bacterial profiles from the normal scheme described.

In the Caspian Sea we met with just such a deviation of the normal vertical distribution of bacteria in the ground.

In 1936 a hydrochemical expedition of VNIRO (Institute of Marine Fisheries and Oceanography) to the South Caspian made a cross-section on s/s «Krasnyi Kaspyi» along the 38th parallel from isl. Ogurchinsky to the central part of the sea. Thereby, both the shallow and deep waters of that region came into the sphere of observations. Ground samples were also taken in the Krasnovodsk bay, not far from the shore.

In taking the samples, Ekmann's tube was used. From the core the ground samples were taken under sterile conditions at 20 cm intervals and seeded immediately onto meat-peptone-agar. At several stations the activity of bacteria in various layers of the ground was estimated by counting the vegetative bacterial cells and the spores separately. The most typical of the results are given in the table.

Station	Distance from the shore in miles	Depth in m	Number of bacteria in 1 cm³ and % of spores in the respective horizons					
			0—5 cm	5—20	20—40	40—60	60—80	80—100
Bay of Krasnovodsk .	0	2	430000/1.4%	—	—	17000/0%	6000/0%	—
South Caspian 46 .	32	14.5	2400/54%	70	0	0	0	0
South Caspian 48 .	95	550	3200/99%	90/90%	50/100%	50/100%	50/100%	0

From these data it is obvious that: 1) for every horizon of the profile the absolute number of bacteria in the ground is higher near to than far away from the shores; 2) the decrease in the number of bacteria with their penetration into the ground is the most strongly expressed in the superficial layer,

between 0 and 20 cm; 3) in the grounds close to the shore the bacteria throughout the thickness investigated (80 cm) occur almost exclusively as active cells; their depth of penetration here is probably well above 100 cm; 4) on the other hand, in the grounds far away from the shore (st. 48), spores of bacteria occur nearly alone both at the surface of the bottom and deep down below; 5) even within the shallow water part of the sea (14.5 m) increase of the distance from the shore goes parallel with decrease in the penetration depth, so that at st. 46 the sterile horizon lies only 20 cm below the bottom surface.

It seemed natural to expect that farther west, in the direction of great depths, the boundary of bacterial penetration into the ground would rise still nearer to the surface of the bottom. However, this is not the case in the Caspian Sea. As a matter of fact, from the 200-m isobaths onwards the sterile horizon goes down again, to reach as low a mark as 80—100 cm at st. 48 and still lower marks at other points, where sea depth amounts to 935 m. We also tested all these grounds for the presence of other groups of bacteria, as denitrifying, desulphurizing etc. which were all found to have exactly the same distribution across the profile of South Caspian grounds.

Now, what reason might be put forward to account for this lowering of the sterile layer in the deep regions of the South Caspian? The most probable explanation is that, owing to the movement of ground at the bottom of this sea, the superficial layers containing bacteria are washed into the South Caspian depression from the adjacent higher places. And as there is no equilibrium in the profile of the South Caspian bottom, the parts above the equilibrium profile will remain liable to erosion until after they have reached this profile. The products of erosion are accumulated in the places lying below the profile of equilibrium.

So, washing out of grounds under the shallow waters of the eastern part of the Caspian Sea and their transfer to the southern depression have been brought to light by bacteriological analysis.

Another instance of how useful this analysis can be in explaining geological factors is furnished by the vertical distribution of bacteria in the littoral zone of the Kola bay. These data were obtained by an investigation of grounds in the region of the Murmansk biological station. The samples were taken from pits dug at low tide at five different points. Here the grounds are formed by the three following horizons: I—very thin layer of oxidized mud, 0.1—0.8 cm; II—black mud, from 2 to 12 cm in thickness, reduced and having a smell of hydrogen sulphide about it; III—very thick layer of bluish-grey plastic clay, with no smell of hydrogen sulphide, lying usually 2.5—5 cm below the surface. Sometimes this layer lies as deep as 20 cm; then it is separated from layer II by an interlayer of shell-bearing clay.

The bacterial distribution in these sharply differentiated horizons is as follows: 1) strong decrease of the content of bacteria in the second horizon compared to the first; 2) absence of any kind of bacteria in the third horizon; no saprophytic bacteria (aerobic or anaerobic), nor any of the other groups investigated, as denitrifying bacteria, *Microspira* or *Clostridium*, could be detected; 3) the sterile layer coincides therefore with a definite genetic horizon, the bluish-grey clay, whose upper boundary is also that of the sterile layer.

A remarkable point in this case is that in the littoral zone rich in bottom algae and midiae and therefore high in organic remains the sterile horizon should come as near to the surface of the bottom as some few centimeters.

Tests have shown that the sterile clay of the III horizon with its pH =8.3 is by no means bactericidal. The development of bacteria on nutrient media is not in the least affected by additions of this clay or its water extract. It is its age and not its chemical nature which have made it sterile. This clay is so

old that not only the vegetative cells of saprophytes and other groups of bacteria have died off in it, but even all bacterial spores have disappeared.

The fact that this sterile clay is so near to the surface of the bottom is unmistakable evidence that the ground in the littoral zone of the Kola bay is being intensively washed out, this process leading to denudation of that old rock. In the Caspian Sea an analogical phenomenon which leads, as has been described above, to a similar bacterical profile, is taking place in the eastern region of shallow waters.

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ARCHAEOLOGY

STUDY AND RE-INTRODUCTION OF MATERIALS AND METHODS USED BY ANCIENT ARCHITECTS IN CENTRAL ASIA

By N. M. BACHINSKY

(Communicated by B. A. Keller, Member of the Academy, 26. XII. 1940)

In course of repair-work conducted on various valuable buildings in Central Asia, in particular in Turkmenia, it has been found necessary to investigate the local building materials whose use was extensively developed in the Middle Ages, while it is almost completely forgotten nowadays. As a matter of fact, it is not so much that the materials themselves have passed into oblivion, as this certainly have the methods of their application, and especially the vast experience and the outstanding skill of the ancient architects who unfortunately failed (with just a few exceptions) to leave their names to posterity. A place of prominence among such materials and methods long out of use, but still worthy of the most careful attention of the Soviet scientist and engineer, is held by ganch, sheresh and reed fillers.

Ganch, gach, gaj, aja—such are the different names of one and the same material, used in different parts of Central Asia and Transcaucasia. In Central Asia it occurs everywhere and is virtually nothing but alabaster with small loess inclusions. It is calcined at relatively low temperatures of the order of 130° C. Calcining is very successful on local fuel, such as dry grass, small shrubs and the like. The operation is as follows: pieces of rock broken out of the deposit are piled up to form a dome-like heap which is then covered with rubble. Heat is supplied through an opening left at the bottom. After cooling, the calcined ganch is ground and then passed through a riddle or sieve. Ganch mortar is prepared in comparatively small amounts: 10—12 kg at a time. Wetting of bricks is essential before laying.

Nothing but ganch mortar was used by the Central Asia architects during a long period of time. Its first appearance dates back to the moment when baked bricks first came into use, i. e. to the tenth century, while the material fell into disuse at a quite recent time only. A great number of structures dating from the X to XX century, all of them consolidated by ganch, have survived to demonstrate the amazing qualities of this material, and the wonderful craftsmanship of the builders. Indeed, we can but admire the method at which these masters of old arrived by a purely empirical way, seeking and finding such solutions of architectural problems, in which simplicity of design was combined with great efficiency of accomplishment.

Ganch binds easily with brick in setting and when dry is never so hard as are lime or cement, though it is never less strong. It is certainly on account

of this plasticity which is a potent factor in resisting earthquakes, that it was so extensively used by ancient builders.

It was used on account of its bending strength, its ability not to break and regain its original shape and qualities in the case when a lot of additional strains are set up in the structure by seismic thrusts and vibrations.

On this consideration was based the ancient practice of widening the mortar joint something up to the thickness of a brick (5—6 cm). In one of the monuments referring to the end of the XIV century—the tomb of Khadji-Akhmat-Jassavi (town of Turkestan, Kazakh SSR) we have found among the big arches supporting the dome of the building, one particular arch consolidated with the help of a mortar of unknown composition, probably a mixture of ozokerite and sand. This mortar was applied while hot and is, indeed, a model of what an ideal quake-proof mortar should be. Owing to purely external reasons, the arch made with this mortar had undergone a marked change of its original ogive shape, ceasing to be equilateral and assuming something of a keel-like form, and with all this, it had not collapse! It was found a very difficult matter to pull the arch down, so viscous was still the mortar after about 500 years of service! This arch had certainly been erected by way of experiment, thus testifying to the fact that the builders were in constant search of new, ever more plastic materials for construction and that, even with ganch at their disposal, they were striving to find something which would give a yet higher standard of perfection. And when using ganch they did not use it always with the same kind of aggregate, but rather varied the aggregates according to the case. Unlike those usually added to cement and lime, these aggregates cannot, with the exception of sand, be called an inert material. Right here let me say that although ganch is known as a hydrophobic material, this is only true to a point. Indeed, it can be made a reliable hydraulic mortar through the addition of suitable aggregates. And just so it was used by the ancient builders. We know examples of very lengthy service of structures consolidated with ganch and subject to an almost continuous action of water. In Bokhara we find functioning to this very day a bathhouse built in the XVI century, in which all the wallwork and floors made of stone with ganch mortar have remained unmolested. Add to this that the bathhouse is heated from under the floor, and it will be obvious that no higher resistance can be expected from the best water-tight mortar.

A brick arch bridge over the Murgab (Turkmenian SSR) consolidated with a similar ganch mortar had subsisted from the beginning of the XIV century up to the end of the XIX, when it was dismantled by the Russians and the bricks were used for building a bakery.

Have we the right to ignore the possible use of this material in modern constructions? It may be remarked that laboratory tests of ganch for compressive and tensile strength yielded results which by far surpass the mean values for high grade cements and lie in the neighbourhood of 100 kg per cm^2.

The usual aggregates added to ganch were loess clay, ground brick, ground charcoal and the ashes of burnt grass. All of these additions were not intended to suit a single purpose and may be classified as follows. Screened loess clay forms, even when taken alone, a satisfactory mortar. When added to ganch in the proportion of about 30%, this aggregate causes no substantial change in the quality of the mortar used in laying walls above the plinth. Ground charcoal and ground brick were used as additions to ganch mortar in laying the lower parts of a building, the foundation and the plinth-wall. These two materials greatly contributed to making the mortar damp-proof. Ash was added for imparting hydraulic properties to the mortar.

But the most interesting admixture to ganch was a root powder from a certain kind of plant, called sheresh (other local names are jirish, chirish, see-

ratch). The plant belongs to the *Liliaceae*, genus *Eremurus*. It is cultivated all over Central Asia and grows wild as far as the extreme south-east of the European part of the Soviet Union. In Central Asia the ground roots of this plant were extensively used as glue, especially by shoe-makers. But as an ingredient in ganch, mortar sheresh fulfils special functions which deserve our closest attention. Even the slightest additions of sheresh powder to the mortar suffice to produce a very considerable effect. In all work with ganch where strength was the prime requisite (e. g. in stucco work, especially engraved stucco, laying of arches, vaults, domes, etc.) sheresh was invariably added to mortar. The additions were, as just mentioned, very small, e. g. only about 0.3 g of sheresh was added to a standard batch of ganch of 12—16 kg. Not only is strength increased with such a portion of sheresh powder, but setting is also accelerated. However, with 2 or 3 g of powder in the same batch, the strength and waterproofness will again be increased, but the setting of the mortar will be this time slowed down. Accordingly, special laboratory tests have been conducted with a view of determining optimum doses of sheresh to be added in order to: 1) increase the rate of setting, 2) reduce the rate of setting, 3) obtain the best waterproofness, 4) increase mechanical strength. Of particular interest is the following observation: in course of microscopical examination (magnification about 430 diameters) it was found that without sheresh a dry mortar was quite different from what it was in the presence of sheresh. A needle-like structure typical of gypsums—many bundles and groups are observed in the field of vision, while in the case of a mortar to which sheresh has been added, we see octahedral crystals displaying an obvious tendency towards close packing.

Such a change in the crystalline structure is indeed a very unusual phenomenon and needs, therefore, verification; but what is definitely known about the effect of sheresh at this juncture suffices to engage our interest.

The problem of replacing a large part of imported cement by local material is of such prime importance for the Central Asia republics, that no suggested solution of it should be left out of consideration. And it is just in the ganch that we seem to have an adequate substitute which can replace cement equally well in aboveground as in underground structures, in those subjected to the action of water as in those having to resist an exceptionally high dryness. In each particular case special properties can, if necessary, be imparted to ganch by the addition of above-mentioned aggregates.

It is worth while to note, by the way, that sheresh forms a source of raw material for the production of first-class glue, a fact which is of definite interest for the Soviet industry. The supply of sheresh is enormous and the quality of the glue derived from it has been known in Central Asia long since.

There formerly existed in Central Asia one more structural device, whose significance can hardly be overestimated, though it is almost forgotten nowadays. Indeed, we feel convinced that at the present time, when large-scale construction work stimulated by the Stalin five-year plans is forging ahead in all parts of the Union, the use of this device ought to form an important link in the sum total of measures directed towards the erection of really sound and efficient anti-earthquake structures. The structural contrivance we are speaking about is: the provision of reed bands or fillers.

In erstwhile architectural practice reed bands were laid in the plinth wall of the building, the thickness of a layer being about 8—10 cm with the stalks running perpendicular to the horizontal axis of the wall. Brickwork was superimposed on the reed band, and it frequently happened that the reeds were covered with an entire layer of ganch mortar, yet not a liquid one, but one of a consistency which simply gave a compact overlying crust. This

latter circumstance deserves special mention, because in constructions of this type the essential point was not to allow the reed and the brickwork above and below it to become an integral whole. Sometimes the reed cushion was topped by wooden beams of *Juniperus excelsa*, instead of a ganch layer. The tree is notorious for its resistance to rot. Then followed courses of bricks laid in the usual way. After erection of the walls, the reed stalks were cut flush with the face of the walls. The rôle of these cushions is of great interest, especially if considered in the light of the attemps made by modern West-Eu opean architects to find an effective type of quake-proof structure.

Schematically the seismic vibrations can be subdivided into vertical thrusts, directed upward, which make the building jump, so to speak; and horizontal thrusts, when seismic activity tends to knock the plinth-wall from under the building.

In both these cases the reed cushion is highly efficient. In the first case it serves as a shock absorber and greatly softens down the thrusts coming from below; in the second case, the foundation and plinth-wall may even undergo certain deformation, without transmitting the strains developed in them to the upper lying wall with which they are not bound into a whole. It is worth recalling here the quake-proof design of a modern Italian engineer who proposed to insert under the plinth two entire steel slabs, between which steel balls were to be interposed. The structure was then to be continued upwards from the second (topmost) slab. This design, so costly complex and at the same time capable of withstanding a single type of thrust only, compares very unfavourably with the Central Asia reed bands. Besides, the latter are also powerful insulators against erosion of walls on strongly alkaline grounds. And in certain localities of Central Asia ground salts are a veritable scourge to buildings, destroying in a few years the plinth part of the structure, eating away the stucco, etc.

As regards the loads that reed bands are capable of sustaining, their high carrying power leaves no room for doubt. In Chor-Bakhr a huge two-storey thick-walled structure has been standing on a reed filler since the XVI century; in Koonia-Urgench we find a mausoleum of about 16 m in height, dating back to still more ancient times and resting to this very day intact on a reed cushioning band. The reed band itself has remained in a good state of preservation without any traces of decay or any other deterioration.

Now, if we take the sum total of anti-earthquake measures adopted by ancient engineers and architects, we will be faced with a consistent, well proportioned and fully logical picture: the foundation is laid with clay which, granted sufficient depth, remains sufficiently plastic; next comes highly plastic ganch, sandwiched-in by a reed shock absorbing cushion; stone or brick courses interlaid with plastic ganch form the rest of the building. It may be claimed that a structure built in this way is most adequately fortified against seismic disturbances, and indeed we see that scores of buildings thus protected successfully withstood all shaking within so long a period of time, proving thereby how very rational the original design had been. At the same time many other edifices built according to other principles have collapsed upon the first shock.

It strikes us that a critical study and subsequent introduction into building practice of the just described building materials and methods may prove highly useful for construction work not only in Central Asia, but in other parts of the Soviet Union, as well.

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